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CONSEIL PERMANENT INTERNATIONAL POUR
L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT, DANEMARK

1935

RAPPORTS

ET

PROCÈS-VERBAUX DES RÉUNIONS

VOLUME CX

CONTRIBUTIONS
TO
SPECIAL SCIENTIFIC MEETINGS
1939

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

Juillet 1939

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PREFACE

At the meeting of the International Council for the Exploration of the Sea in 1938, the following Recommendation was made by the Consultative Committee and passed by the Council:

> "That the subject for the Scientific Biological Meeting next year should be the study of the relation between catch and intensity of fishing discussed from both a theoretical and a practical standpoint ...."

The meeting recommended took place in Berlin on May 11th 1939, under Chairmanship of the President, Professor Johan Hjort, who opened the meeting with some introductory remarks and briefly commented on each of the lectures summarized by the contributors. All contributions except those by Dr. E. Fischer and Dr. Aage J. C. Jensen had been distributed some weeks before the meeting. In addition to those specified in the list of contents overleaf, Dr. H. Blegvad gave a lecture on "The Danish Transplantations of Plaice and their Influence on the Stock of Plaice in the inner Danish Waters" and Mr. Paul Bjerkan gave a preliminary report on some experiments by Mr. G. Rollefsen in the rearing of plaice larvae (see Vol. 109, III·26).

In the afternoon sitting the idea of publishing a special annual report: the "Annales Biologiques", was discussed. The discussion was opened by Prof. Dr. Hagmeier, who read a paper on: "Die Bedeutung des 'Ökologischen Jahresberichtes' für die Arbeiten der Internationalen Meeresforschung" (see page 107). After the following discussion, the question was referred to the Chairmen of the several committees, and at the final sitting of the Consultative Committee the proposal was adopted (see report of this committee, Rapp. et Proc.-Verb., Vol. 109, I, page 27, pt. 5).

In connexion with the session was given a series of colour-films from Greenland, taken and presented by Mr. Paul M. Hansen of the Greenland Directorate, showing the life of the Greenlanders and their fisheries, and a film showing a historic development of the German North Sea Shrimp Fishery and related Industries was presented by Dr. P.-Fr. Meyer.

The meeting was attended by Herrn Staatssekretär Backe from the "Reichsministerium für Ernährung und Landwirtschaft"; Mr. Backe expressed his Government's interest in the international fishery investigations and wished the Council success in their work. Professor Hjort thanked him and his Government and expressed his pleasure in seeing scientists from so many countries assembled in such friendly co-operation.

Administrative Secretary.

1.

AN ELEMENTARY TREATMENT OF THE OVERFISHING PROBLEM.

BY

E. S. RUSSELL.

IN the early days of fishery research we were inclined to think that a diminution in the catch per unit of fishing effort, especially if continuous and severe, was by itself an indication of overfishing. Now we know that this is not the case. A diminution in the yield per unit of effort is a necessary consequence of the increasing exploitation of a stock of fish, but does not by itself indicate overfishing.

If we start with an unfished or virgin stock, and gradually increase the amount of fishing, we get for some time a continuously increasing yield, accompanied shortly by a decreasing catch per unit of fishing effort. But the yield does not go up in direct proportion to the amount of fishing; the ascending curve of yield begins to flatten out, and there comes a time when a maximum yield is obtained. Thereafter, if fishing is still further increased, the total yield falls off. That is what we mean nowadays by overfishing — the state in which the more you fish the less you catch.

Thanks to the accumulation of international statistics over a sufficiently long period of years, it is now possible to demonstrate that, in several important demersal fisheries in the Council's area, a state of overfishing has set in — an increased amount of fishing has resulted, not in an increase, but in a decrease, of total yield.

I propose first of all to give some examples of existing overfishing, and then to demonstrate by a simple arithmetical method in a theoretical case the rather obvious reason for the decline in yield that occurs when the intensity of fishing oversteps its optimum.

By way of introduction, let us contrast the state of affairs in a stock which has been fished very little with that in a stock which has been thoroughly fished for many years. We are fortunate in possessing some measurement-data relating to the stock of plaice in the Barents Sea in 1907, a year or two after commercial trawling had started in that area. We owe this valuable information to Mr. G. T. Atkinson, who made a voyage there on a Hull trawler.

Atkinson found that the plaice population consisted almost entirely of large mature fish, showing in this respect a marked contrast with the conditions prevailing at the same time in the North Sea.

From the diagram (Fig. 1) we see the size-distribution of over 2,000 female plaice measured by Atkinson in the Barents Sea. They are mostly fish over 40 cm. in length, and mostly mature.

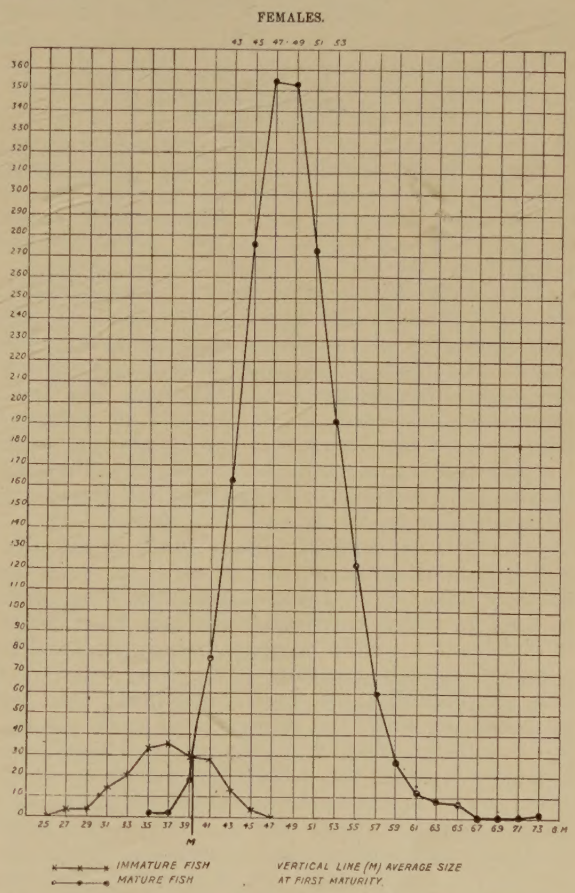


Fig. 1. Showing the length frequencies in 2 cm. groups of 2,125 female plaice. Barents Sea, August, 1907. (From G. T. Atkinson, Notes on a Fishing Voyage to the Barents Sea in August, 1907. Journ. Mar. Biol. Assoc., VIII, p. 79.)

Compare in Fig. 2 the length-frequencies of some 900 female plaice from the North Sea, as determined about the same year.

Here the fish are mostly less than 40 cm. in length, and the proportion of mature is very much smaller than in the Barents Sea. The average size at first maturity is approximately the same in both cases, namely 39—40 cm.

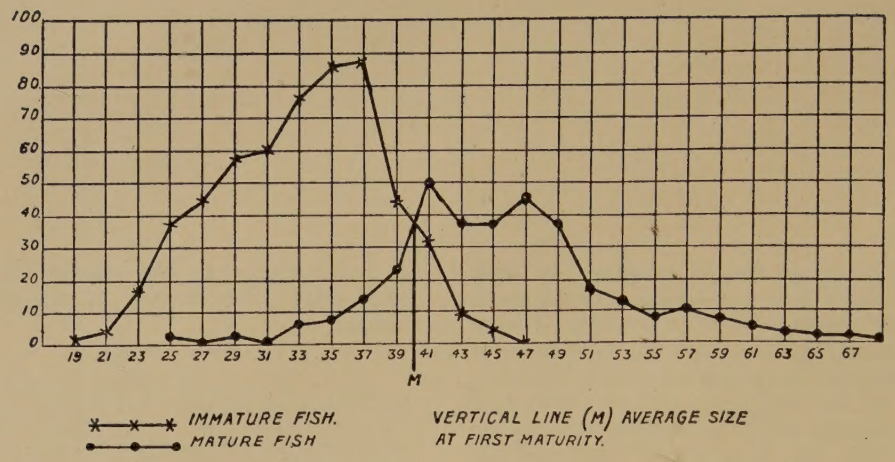


Fig. 2. Showing the length frequencies of 895 female plaice from the central grounds of the North Sea (Dogger Bank, Clay Deep, etc.). (From G. T. Atkinson, Notes on a Fishing Voyage to the Barents Sea in August, 1907. Journ. Mar. Biol. Assoc., VIII, p. 90.)

The difference between the two populations is of course due, in the main, to the fact that the exploitation of the northern stock had only just begun, and fishing had made little impression on the stock, whereas the North Sea stock had been, even then, subjected to many years of intensive fishing, with the result that the number of large and old fish was very much reduced. Mortality due to fishing was high in the North Sea stock, but relatively low in the Barents Sea stock.

The rate of mortality shows itself in the size- and age-distribution of the stock — that is the primary lesson to be learned from this comparison of a virgin and a heavily fished stock. If mortality is high over a period of years, this is reflected in a reduction in the numbers of the older and larger fish. If mortality has been consistently low, the proportion of older and larger fish is much greater. We may judge, then, from the age- and size-distribution of a stock, the order of mortality to which it has been subjected. If we find, for example, that the proportion of large fish in a well-fished stock is steadily decreasing over a period of years, we can fairly safely draw the conclusion that the intensity of fishing is increasing. I use this criterion of intensity of fishing in my first two examples. We have, unfortunately, in most cases, no accurate information as to the total amount of fishing in any region and its changes from year to year, and it is necessary therefore to fall back upon this indirect method. It must of course be used with discretion. Its validity depends too upon the assumption — which I think is thoroughly justified under present conditions of fishing — that mortality due to fishing is considerably greater than natural mortality, within the size- and age-range subjected to fishing operations.

Let us consider now some general statistics relating to the haddock fishery in the North Sea, and let us see whether there has been an increase in mortality rate due to increased intensity of fishing.

Table 1.

Haddock. North Sea.

Landing per Day's Absence.

	Cwt.		Cwt.		Cwt.
1906	7·8	1919	15·8	1929	5·2
7	7·8	20	10·9	30	6·3
8	6·9	21	9·6	31	4·8
9	5·9	22	8·5	32	4·5
10	4·9	23	5·4	33	4·6
11	5·3	24	4·8	34	2·7
12	4·7	25	8·5	35	1·9
13	3·0	26	8·2	36	2·1
14	4·6	27	5·9	37	2·6
		28	5·4		

In Table 1 we have the landings per day's absence by English steam trawlers from 1906 to 1937. The pre-war values show a downward trend but give an average for the eight-year period, 1906 to 1913, of 5·8 cwt. In the first year after the war we get the very high value of 15·8 cwt., and the mean of 1919 to 1921 is still high at 12·1 cwt. These high values are no doubt due, in the main, to the increase in the stock during the war years, when the intensity of fishing was greatly reduced. If we assume that the effect of the war was negligible after 1921, and group the remaining 16 years in two 8-year periods, we find that the average value of the landing per day's absence was, in 1922—1929, 6·5 cwt., but only 3·7 cwt. in 1930—1937.

We are taking the landing per day's absence by English steam trawlers as an index of the density of the haddock stock in the North Sea. This is not entirely satisfactory, for they do not sample the whole area evenly, and the values are calculated from the total number of days absent, whether the trawler is making haddock a main objective or not. But the data are, I think, sufficiently good to indicate the broad changes in the stock.

Accepting this index as reasonably accurate, we see that the stock had increased very greatly by the end of the war. It then decreased fairly rapidly, reaching values in 1923 and 1924 which were below the pre-war mean. For the period 1922 to 1929 the stock was apparently a little more dense than in pre-war years, but we must remember that during this period the efficiency of the trawl was increasing, owing to the introduction of the Vigneron-Dahl principle. It is difficult to assess accurately the effect of this improvement in gear, but we should be on the safe side in estimating the general efficiency of the V. D. gear, in its various modifications, to be at least 25 % more than that of the ordinary trawl.

In the period 1930 to 1937 the stock of haddock was heavily reduced, for the landing per day's absence fell to an average of 3·7 cwt., uncorrected for the effect of the V. D. gear.

Before we conclude that this big drop in the density of the stock was due entirely to increased intensity of fishing, we must of course consider the effect of the big fluctuations in the supply of new brood, which are known to exercise a great effect upon the catches. The fluctuations, since the war, are fortunately very well known through the work of Bowman, Harold Thompson and Raitt. They show themselves in the commercial catches about two years after their occurrence, and first of course in the smallest category of fish. But as nowadays the small fish form the bulk of the catch the effect of the fluctuations is seen clearly in the landing per day's absence of all categories.

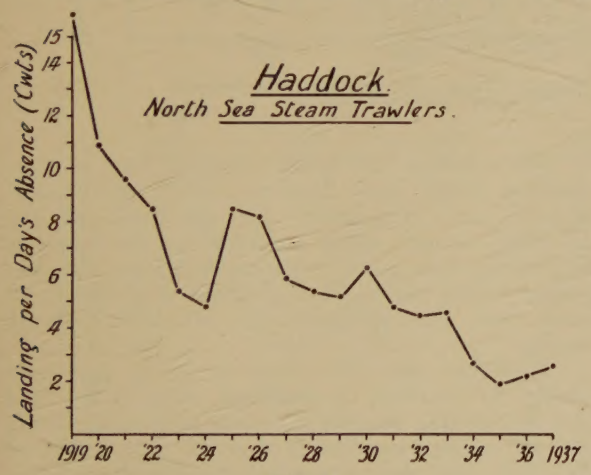


Fig. 3.

Figure 3 shows a curve of the landings per day's absence in the period 1919 to 1937.

You will see that the trend is very definitely downwards, rapidly at first, then slowing off. Superimposed, as it were, on this descending curve there are plus and minus variations, which reflect in the main the effect of the good and bad brood years. There is for instance a marked negative variation in 1923 and 1924, which is attributable to the bad brood years of 1921 and 1922. The plus variation in 1925 is due to the influence of the good 1923 year-brood. The rise in 1930 is likewise explicable by the influx of the rich year-class produced in 1928, and the low values in 1934 to 1936 reflect the poor year-classes of 1932 to 1934. Now the magnitude of the fluctuations in brood or fry was not markedly different in the later years from what it was in the earlier; the most productive year of all was actually 1928. It is true there is a period of low brood production from 1929 to 1934, with only one good year — 1931. But it will be noticed that the plus and minus variations which show the effect of natural fluctuations do not seriously modify the downward trend of the curve, and that they become less marked in the later years. There is clearly some other cause for the general decline in the stock, and this can only be the increased intensity of fishing. And we can get indirect evidence of this increased intensity by considering the changes which have taken place in the size-composition of the catch, as indicated by the relative proportion of the statistical categories, large, medium and small into which the fish are divided. We assume of course that the size-composition of the landings indicates the size-composition of the stock, or rather, of that part of it which is above the minimum size of landing.

If now we take the average percentage of Small for the pre-war eight-year period, we find it to be 50. It is little different in the immediate post-war years, but in the period 1922 to 1929 it is just over 70, while in the latest eight-year period it rises to over 85. In 1936 and 1937 it was over 90. The percentage of Large fell fairly steadily through the whole post-war period, from over 20 right down to 3 and 2 in the last two years. There has therefore been a very big change in the size-composition of the landings, and, by inference, in the size-composition of the stock. We must remember that the percentages relate to weight of fish, and that if turned into numbers the growing preponderance of Small would be even more marked. Now these data, rough and approximate as they are, undoubtedly show that the rate of mortality in the stock has considerably increased. We have independent evidence to show that mortality due to fishing is very high, and much outweighs mortality due to natural causes, during the years of life when the stock is subjected to fishing operations. Fishing is

then the main cause of mortality. We may therefore conclude with reasonable safety that the intensity of fishing has increased in that part of the North Sea where haddock are found, and that this is the main cause of the diminution in the weight of the stock on the grounds and the decrease in average size of the fish.

We have deduced this by using the statistical data relating to one only of the fisheries for haddock in the North Sea. We must now consider what has been the total yield of haddock from the North Sea during these various periods, and for this purpose we must bring in the catches of other countries. For the period 1910 to 1913 the average annual yield was 121 million kilos. It dropped of course during the war, though not so much as one would have expected, and the average yield in the three post-war years was 195 million kilos. For the period 1922 to 1929 the average annual yield was 128 million kilos, but for the period 1930 to 1936 (the latest year for which such data are available) it was only 94 million kilos.

We may draw the important conclusion that increased intensity of fishing has in this case resulted in a diminished catch. That is over-fishing. Exactly why this, at first sight, paradoxical result comes about — and must come about — I shall explain later.

The available statistics of the **hake** fishery, though not so complete internationally as those for the North Sea haddock fishery show, since the war, just the same thing — a heavy reduction in the landing per day's absence by English trawlers, a marked diminution in the percentage of large fish, and (excluding Spanish and Portuguese landings) a very serious falling off in total yield. A state of overfishing has definitely set in.

Here are the details. In the three years after the war average landing per day's absence by English steam trawlers was 2·8 cwt., and the percentage of large fish was 49. In the eight-year period, 1922 to 1929, these values were respectively 2·7 cwt. and 22 % of large. In 1930—1937, these values fell to 1·6 cwt. and 10 %. There is clear evidence here of increased intensity of fishing. Changes in the total yield of the fishery are difficult to estimate, for the Spanish and Portuguese landings are not available for any long and continuous period. But if we leave these out of account, we find that the landings by other nations averaged 63½ million kilos annually in the period 1922 to 1929, but fell to an average of 41 million kilos in the period 1930 to 1936. There was in fact an almost continuous decline from 1925, with 80 million kilos, to 1935 with 32 million — a decrease of no less than 60 %. — There was an increase in 1936 to 37 million. — Let us turn now to the trawl fisheries in Icelandic waters. There has been since 1925 a marked increase in the amount of fishing by English trawlers, as is shown in Fig. 4.

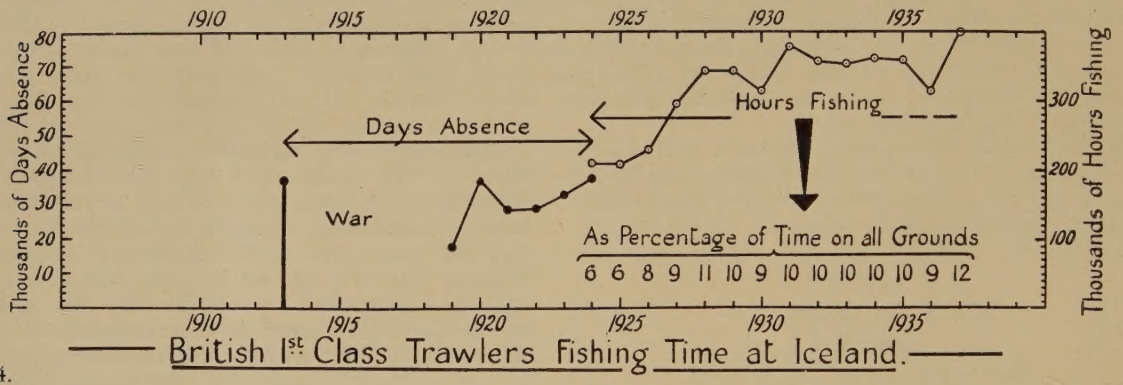


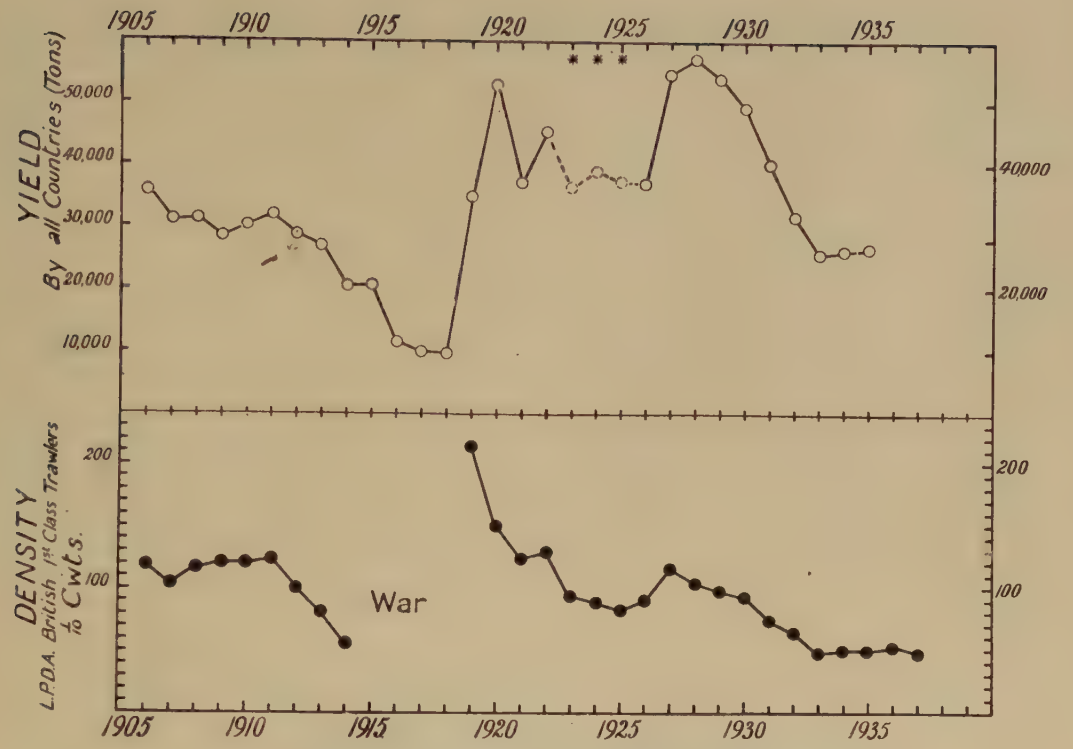
Fig. 4.

The number of hours' fishing has in fact doubled itself from 1925 to 1937. As English trawlers are responsible for the bulk of the landings, we may safely conclude that the intensity of fishing has greatly increased during the last ten or twelve years. The introduction of the V. D. trawl has also increased the efficiency of the vessels.

What has been the effect on stocks and total yield? If we take the **haddock** (Fig. 5) we find that the landing per day's absence fell rapidly from its high value immediately after the war, recovered in 1927, and then decreased steadily to reach a stable value of about 5 cwt. in 1933 to 1937. The stock had markedly decreased in density. Total yield reached a peak in 1928 and then showed a marked and steady fall till 1933, and little change in 1934—36. Thus we get, with an increase in the intensity of fishing, a fall instead of a rise in total yield.

Much the same thing is shown by the **plaice** in Fig. 6. There is the same steady decrease in the landing per day's absence, and the catch per 100 hours' fishing has fallen from 56 cwt. in 1922 to 18 cwt. in 1937. The total yield has also diminished since 1931, though not to a great extent.

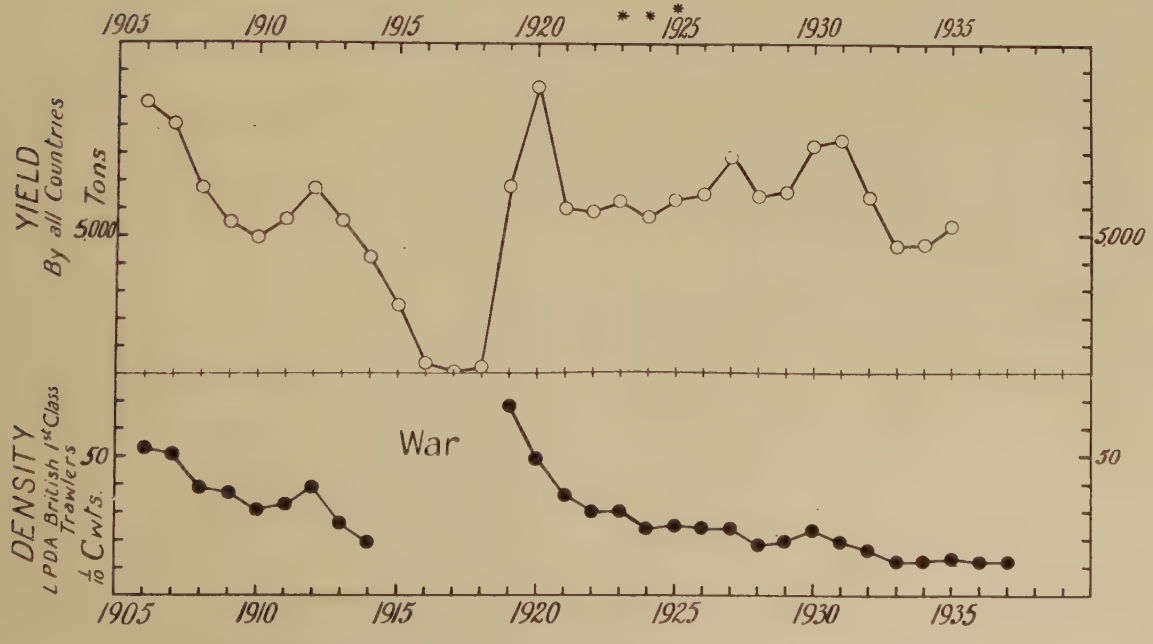
(1)



—Haddock from Icelandic Grounds.—

*Iceland's Share not available 1923-25; so estimated

Fig. 5.



—— Plaice from Icelandic Grounds. ——

*Iceland's share from Dr Tåning's MS.

Fig. 6.

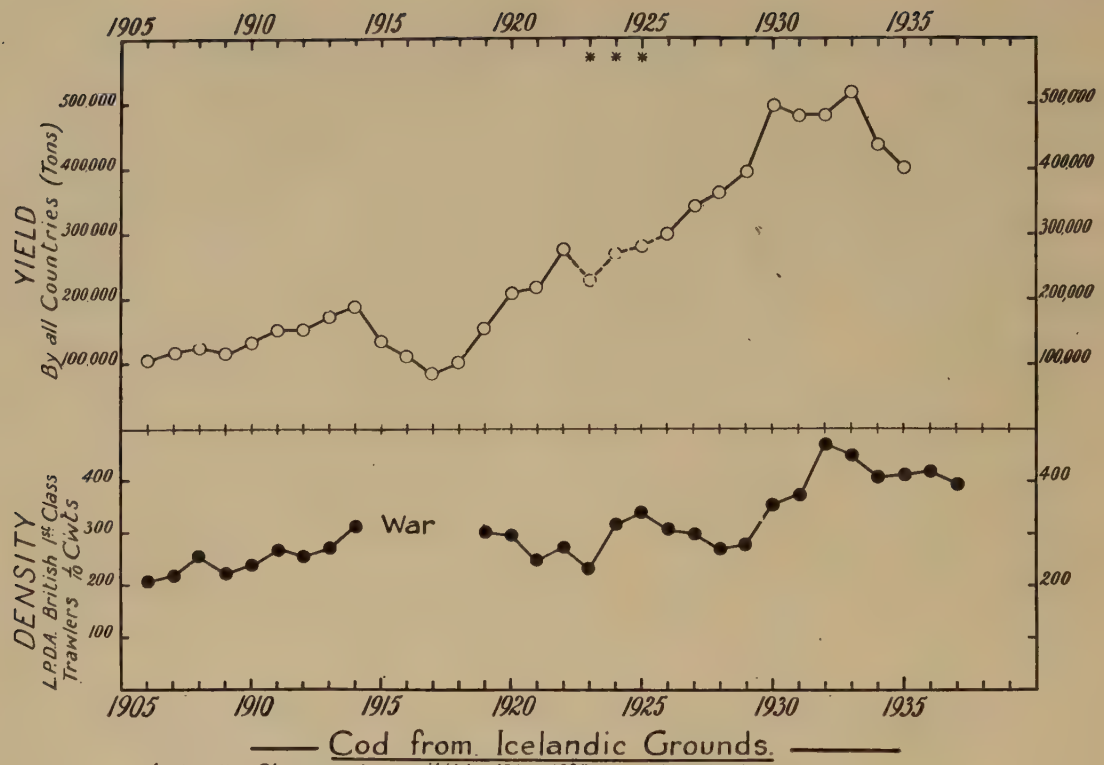


Fig. 7.

The **cod** gives us a different picture (Fig. 7). Total landings show a steady increase since the war, up to 1933, and the landings per day's absence also tend to rise, reaching a peak in 1932 and falling off somewhat to 1937. This is clear evidence that the density of the stock has greatly increased, up to 1932, through natural causes, in spite of the increased intensity of fishing. We know of course that in Icelandic waters, as in the waters of the far north, the stock of cod has actually increased owing to large-scale hydrographical changes, resulting in a great extension of its normal range.

But even in the cod fishery in Icelandic waters there is some indication that fishing is having its effect in reducing the abundant stock, for both total yield and the landing per day's absence are on the down-grade since 1933.

I have now given some examples of actual overfishing, where with increased intensity of fishing we get a diminution of yield. While natural cases may affect the magnitude of a stock, as we see in the case of the Icelandic and Arcto-Norwegian cod, and in the fluctuations in haddock broods, there is little doubt that in the haddock and hake for example, and also in the plaice, the decrease in density of the stock which leads to a state of overfishing is in the main due to increased intensity of fishing.

It is not difficult to see why too much fishing results in diminished yield. The fish are not given time to grow up, and the annual upgrowth, which is mostly removed as catch, is not as great as it might be.

It is fairly obvious that if we wish to obtain the maximum *steady* yield from a stock we must fish neither too much nor too little, but at an intermediate rate, such that the number caught multiplied by their average weight, is, and remains at, a maximum. If we fish too little, we do not catch a sufficient number to give us the maximum steady yield in weight. If we fish too much, the average weight of the fish caught is too low to give us the maximum yield.

This proposition is almost self-evident, but I propose to illustrate and prove it by considering what would be the yield from a theoretical stock of fish subjected to different rates of reduction through fishing.

Let us take first the following simple diagram (Fig. 8) which is copied from a recent paper by Dr. W. F. Thompson, who has done so much good work on the overfishing problem. This shows the effect upon an original stock of 1,000 fish of annual percentage reductions in number of 50 % and 80 %.

We take this first of all as referring to a single year-group of fish. The diagram is self-explanatory,

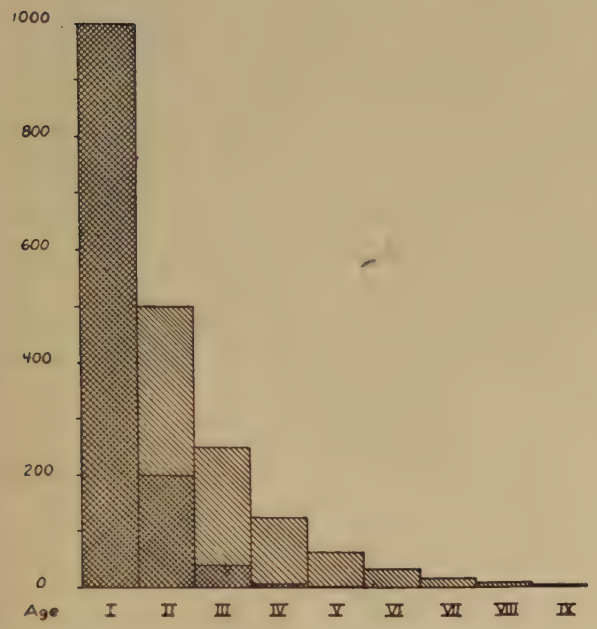


Fig. 8. Diagram showing the relative numbers of fish of each age in two stocks, one subject to a removal of 50 % yearly, one to a removal of 80 %. (From W. F. Thompson, Theory of the Effect of Fishing on the Stock of Halibut. Rep. Internat. Fish. Comm., No. 12, Seattle, Washington, 1937.)

and the numbers withdrawn from the stock each year on the 80 % and the 50 % reduction rate are as shown in columns 2 and 4 in Table 2. If we assume that the rate of natural mortality is considerably less than the rate of fishing mortality, the withdrawals may be taken to represent with reasonable accuracy the numbers caught each year. If now we know the average weight of the fish in each year of life, we can calculate the total weight of the withdrawals, the bulk of which will be catch.

Table 2.

	Stock	Withdrawals of 80 % annually	Stock	Withdrawals of 50 % annually
Age I	1000		1000	
II	200	800	500	500
III	40	160	250	250
IV	8	32	125	125
V	2	6	62	62
VI		2	31	31
VII			16	16
VIII			8	8
IX			4	4
X			2	2
XI			1	1
Totals	1250	1000	2000	1000

But before we interpolate values for weights, it is important to realise that Fig. 8 can be used in a different and more significant way. If we assume that we are dealing with a completely stabilised fishery, and that the number of incoming recruits is constant, then this diagram represents the age-composition of the stock at the time of year just before the recruits enter the catchable stock, age-group-I being yet untouched by fishing. And if the amount of recruitment is constant, and also the rate of growth and rate of reduction, then this same picture represents the state of the stock *each year* at the same period. The withdrawals will then represent in numbers and ages what is taken from the stock *annually*, mostly in the form of catch.

I propose now to compare the yield in terms of weight of our theoretical stock under a 50 % and an 80 % reduction, and I shall use as values for weight in relation to length the average values established for haddock in the North Sea, prior to 1928. These are as follows:—

End of 1st year	40 g.
2nd	124
3rd	227
4th	339
5th	460
6th	586

For the average weight of the fish between 1 and 2 years old I take the mean of 40 and 124 grams, namely 82 g., and so on for the subsequent years. Using mean values for weight it is easy to calculate the total weight removed annually from our theoretical stock on the 50 % and the 80 % scale of reduction respectively. The 50 % reduction gives us a total weight of withdrawals amounting to 161,263 g. from the five year-groups considered. The corresponding total weight for the 80 % reduction is considerably less, namely 106,102 g.

If we assume that natural mortality is not of a high order, the bulk of these withdrawals must be catch, and we can safely infer that the yield from this theoretical stock when fished at the lower rate is considerably greater than the yield when the stock is fished at the higher rate. Fished steadily at the lower rate, the stock is stabilised at a much higher level of average size and age, and it can thus yield continuously a greater annual catch than the more intensively fished stock.

Similar calculations for a percentage reduction of 40 and 66⅔ give values of 177,148 g. and 128,188 g. respectively.

Let me recapitulate these results. Removing 40 % annually we get a total of about 177,000 g., 50 % 161,000 g., 66⅔ % 128,000 g., and 80 % 106,000 g. Assuming that the mortality is mainly due to fishing, we can infer that the lower rates give actually a greater yield than the higher.

We may safely draw the conclusion from

this purely hypothetical case that there must be for every stock of fish an optimum rate of fishing, which will give the maximum steady yield (subject, of course, to variations due to natural fluctuations, which, however, cancel out over a period of years, and to variations in growth-rate). If the rate of fishing exceeds this optimum the yield will fall in spite of the extra effort expended. This extra effort is, in fact, wasted.

In order to forestall criticism, I should point out that two assumptions are made in our treatment of the theoretical case which are probably not justified. We have assumed that the original or recruit stocks are of the same magnitude, whatever the rate of reduction, and that the rate of growth is also the same. Both these assumptions are open to objection. There is, in fact, definite evidence, both for plaice and for haddock, as is clearly shown in the papers by Dr. Bückmann and Dr. Raitt, that rate of growth does alter considerably according to the density of the stock, being depressed when the stock is dense, and increasing when, through poor recruitment or increased intensity of fishing, or both, the stock is heavily reduced in numbers. So our calculations ought to be corrected for this variation in growth-rate which we may expect to find in actual stocks. Thus, growth-rate would probably be greater in the stock subjected to the 80 % mortality, and we should therefore use greater average weights in our calculations, obtaining thus a greater theoretical yield for this rate of removal. In other words, the bad effect of over-fishing is counteracted to some extent by the enhanced growth-rate brought about.

Still, our general conclusion remains valid — that too much fishing must result in a diminished catch.

There is another important point which can be demonstrated *in principle* by the use of our theoretical case, and that is the value of protecting the smaller fish from capture. It is obvious that a year-class of fish, after it has survived the heavy mortality incidental to its early life, will, if protected from fishing, increase in total weight for some years, the loss due to natural mortality being well overcompensated by the growth of the survivors. It is, therefore, desirable to let the year-class grow up to near this maximum weight before beginning to capture it. That is the real case for protecting undersized fish from capture. That such protection must increase the yield can be demonstrated in our theoretical case. We assumed, you will remember, that this theoretical fish was exposed to capture as soon as it entered its second year of life. Let us now assume that all the fish are protected between one and two years old, and let us take the reduction in numbers during this year, due to natural mortality, as 20 %. Our stock will then be 800 at the end af the second year, and we will assume that this stock is then fully subjected to fishing operations. (This is of course an over-simplification.)

On the 50 % scale of reduction, the removals (of which the bulk is catch), are obviously 400 between 2 and 3 years old, 200 between 3 and 4 years, and so on. If we convert into weights we get a total up to the end of the 6th year of life of 192,750 g. per 800 two-year old fish. This is considerably greater than the 161,000 g. yielded by fishing the stock from the beginning of its second year. There is, therefore, as one would except, a distinct advantage in delaying capture by one year.

If we apply the 80 % reduction to the stock of 800 two-year old fish, we get a total weight of withdrawals up to the end of the sixth year of life amounting to 161,039 g., again much greater than would have been yielded by fishing the stock as soon as it was one year old, which would have given about 122,000 g.

It is to be noted that the 80 % scale of reduction yields less than the 50 % scale even in this protected stock. On the other hand, protection for one year raises the yield from the 80 % rate up to the level of that from a 50 % reduction on the original unprotected stock. Accordingly, an effective protection of the earlier year-groups counteracts to a considerable extent the ill effects of overfishing, although the protected stock may still be overfished.

Summing up this short discussion, in which only the bare essentials of the problem have been considered in an ultra-simplified form, we may conclude, I think, that in many of our demersal fisheries there are two things wrong. There is too much fishing, and the fish are being caught too young. The two evils are closely related. We can, through the machinery provided by the International Convention on Mesh and Size Limits, do much more than we have done to protect the undersized fish from capture, and so help to build up the stocks. But the only final solution of the over-fishing problem is to limit the amount of fishing, for the only real cure for fishing too much is — obviously — to fish less. As you are well aware, the plan of limiting the total amount of the catch has been put into operation in the Pacific halibut fishery, under a Treaty between the United States and Canada, and has achieved striking results in the recovery of the stock and a marked increase in the yield per unit of fishing effort.

This is a splendid object-lesson for us.

2.

THE SIGMOID CURVE AND THE OVERFISHING PROBLEM.

BY

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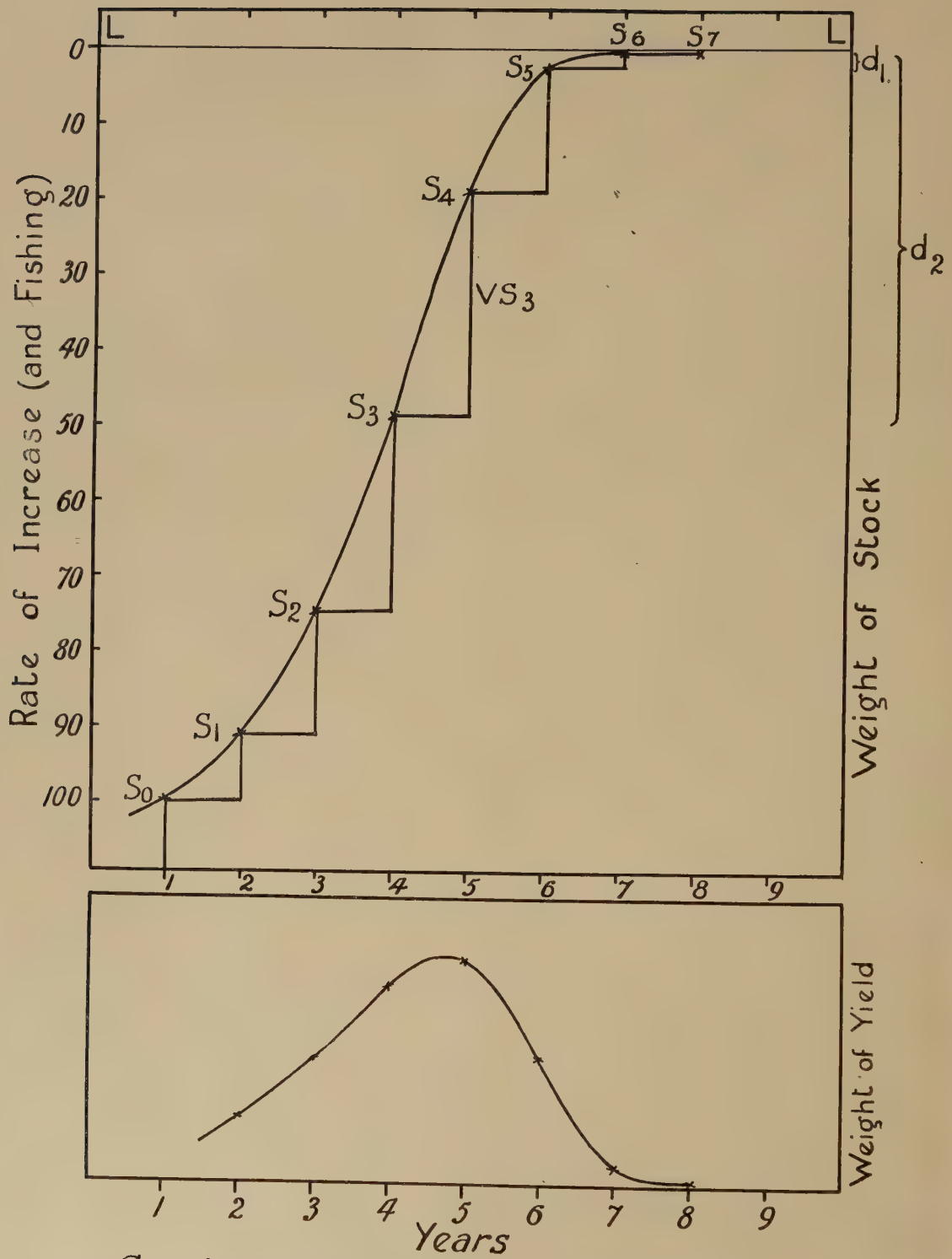
OVERFISHING has been studied for many years and, on the whole, understood. Ever since Petersen's work on plaice in Danish waters there has been general agreement that it must pay the industry to allow the fish to grow to a medium size. Although authoritative opinion has been agreed to that extent, it is fair to add that different studies revealed a certain number of loosely connected and sometimes contradictory conclusions. For example, almost everyone thought it wise to protect younger fish by mesh regulations or other methods: but there remained a few workers who pointed out that "thinning" of these same fish should result in increase of growth-rate, and therefore of productiveness. This argument was soundly based in itself, but the question was how much effect it had[1]). Such differences of opinion did not prevent agreement that at least some small degree of protection was advisable, and even urgently necessary. In this matter, however, — and in other ways — the subject called for some guidance, in estimating opposing tendencies and disentangling the more quantitatively important processes from those which are of smaller magnitude.

In 1930—1935 the subject was developed on lines which seem to give a first approximation to a solution of the outstanding difficulties. We may refer to papers by Baranov; Meek; Russell; Hjort, Jahn and Ottestad; Thompson and Bell, and the present author. The contribution of these papers was, in the first place, theoretical, but the theory that has emerged is so simple and in consonance with so many known facts that it is fair to think of it as a natural law that serves to summarize observations, rather than as a product of scientific imagination. The modern formulation has just been explained in Dr. Russell's paper. Dr. Bückmann has also set the whole matter out very clearly in his paper of 1938. If we wish to put it formally we could say that *the productiveness of a stock of fish depends on the effort used to exploit it; the productiveness first increasing and then decreasing as the effort increases.*

[1]) Papers by Garstang (Buckland Lectures, 1930) and Bückmann (1932) may be cited in this connexion.

This law could be derived, with very few steps, from the writings of Petersen as long ago as 1894. Many workers have contributed their part in the meanwhile, including especially Baranov in his paper of 1916. The modern formulation is indeed only the natural culmination of work in the years that have passed. Proof of this lies in that the two kinds of data which Dr. Russell has just used have been collected all the time. One kind is the grand total of international statistics of weight of fish landed, which Sir D'Arcy Thompson has summarised year by year in *Bulletin Statistique*. It is, perhaps, not out of place to recall his insistence that — in spite of the many difficulties in details, important in themselves, but of small account in the total — the grand totals and smooth averages represent trends and phenomena that have a real and important meaning. The other kind of data is the statement of age-composition and growth, of which the importance has been so strongly urged from the very beginning by Professor Hjort. From such statements, combined with marking experiments, it is possible to say with certainty if a particular stock of fish be over-fished; though these methods are unsuitable for calculating any yields remote from that observed, such as the optimum catch. In addition to this vitally important work that Professor Hjort has so long supported — both by precept and example — he has, in recent years, rendered another conspicuous service. It was a remarkable piece of insight to realize that the problem of the growth of populations of yeasts was fundamentally the same as the problem of the fisheries. In collaboration with Jahn and Ottestad he thus came to introduce into fishery science, the sigmoid curve, of which the importance will become clear as we proceed.

The sigmoid curve can be derived graphically, without advanced mathematics. We start by considering a very small stock of fish in an empty area of the sea, the total weight of the stock being represented in the diagram by the ordinate at S_0. We shall consider at what rate such a stock will increase its weight. Let us suppose that it is capable of increasing at a rate of 100 % per annum. In that case the ordinate at S_1 may be taken roughly



Graphical Derivation of an S-shaped Curve.

as double that at S_0. Now let us consider what the rate of increase will be at this new point. The stock has increased in weight from S_0 to S_1 and it is reasonable to assume that the initial rate of increase cannot continue indefinitely. In any given area there must be a limit to the weight of fish flesh that the area will support. Such a limit is represented by the line LL.

Returning now to the stock S_1, it is observed that the weight of stock is nearer to the limit than it was before. It seems that the new rate of increase will not be so great as the old, but will in some way depend on how much space there is left in the area. The simplest assumption we can make is that the rate of increase is proportional to the difference between S at any moment and LL. In that case we may write zero rate at LL and divide the scale on the left of the diagram accordingly.

It then appears that the rate at the point S_1 is 92 %, so S_2 can be obtained roughly by adding 92 % of S_1. At S_2 the rate is 75 %, but the ordinate to which this is applied is of considerable magnitude, so that a still larger increase is recorded. If this process is continued an S-shaped curve of growth of stock results.

When a fishery begins in an untouched area we expect the stock to be represented by some high point on the S-shaped curve. At such a point the amount of natural increase is small, represented by a little height such as that at S_6. The fishermen, however, take more than this away and the stock is driven down the S-shaped curve. If it reaches a point such as S_3, the stock is capable of increasing at 50 % per annum. If the fishing is also at that rate, there will be no increase of stock, but the catch will equal the increase there might have been were there no fishing. If the rate of fishing stays constant, an equilibrium will be established, in which the stock remains at S_3, the rate of fishing at 50 % of the stock and the total yield per annum at 50 % of S_3, represented by the vertical distance VS_3.

Similarly, at all other points, the heights of the construction triangles represent the yield by steady fishing at different rates. So we may represent the yield by another curve below the S-shaped curve, joining the tops of these heights that have been plotted separately, and this curve, in the limit, is that of differential coefficients.

In deriving these curves in this rough and ready way we introduce asymmetry. If the time intervals are taken sufficiently small, or if we apply compound interest instead of simple interest, the diagrams become symmetrical.

So we see that as the fishing effort becomes greater, and the average age of the stocks becomes less, the yield of which such stocks are capable first rises and then falls.

This conclusion is similar to that of the calculations shown by Dr. Russell. The advantage of using the sigmoid curve is that we have made a reasonable theory to include variation of rates of growth, recruitment and mortality. Here, as in Dr. Russell's paper, the "yield" is the total yield per annum of all fishermen. The catch per unit of effort is proportional to the stock, that is, it is represented by the sigmoid curve itself, not by its first derivative.

The fitting of these curves to actual fisheries is a matter of some difficulty. In one case, that of the combined trawl, line and seine fisheries of the North Sea, the experience of the war time respite has enabled the fitting to be carried out; but in a way which can at best give only a rough estimate of the optimum catch. There is good reason to believe that it is an underestimate. The estimate is that the maximum yield of the North Sea demersal fisheries would be 15 % above that of recent years. This somewhat greater yield, however, would be taken by a reduction in the rate of fishing of 25 %.

Dr. Russell has given several striking examples which show that the theory represented by the sigmoid curve is in conformity with our experience. In general, too, we know that, when there is a small fishery by primitive methods, it can be carried on indefinitely without any harmful change, as has been done for time immemorial in the Great Lakes of Africa. When, however, the enterprize that the industrial revolution has brought to the fisheries has scope, the history is, in all cases, similar. At first, pioneers make enormous catches for their single efforts and, when others join in, a great industry develops with individual catches smaller than at first, but total yield larger. If there is anything like stability in effort, the yield shows remarkably little trend at this stage, although it fluctuates. Let some new invention or organisation be adopted, which temporally increases the catch per £ expended: very soon the yield is no greater, perhaps even less than before. It seems not an unreal explanation to say that the stock has been driven down the S-shaped curve, to a point of less productivity.

If it can be accepted that the theory of the sigmoid curve is reasonable, there will be some puzzling questions for future consideration. For example, the theory has so far been applied to the demersal fishes that are important as human food, that is excluding herring and useless species. Since haddock and cod, at any rate, are predators of herring and their spawn, it might be better to include the herring with the other fish flesh. Then, as regards the less useful species such as dab and *Callionymus*, these cannot altogether be excluded from consideration. For the time being I suggest the following argument:— As the stock of food fishes is reduced, these other species probably increase. This amounts to a lowering of L L, which may be presumed to be reversible. For this reason alone, the case is probably more complicated than has been assumed here.

We can, however, be sure that the law of dependence of yield on effort, with an optimum catch at some intermediate level of effort, holds good. I should like to take a little time to consider some of the implications of this law.

Firstly, *no means whatever can bring permanent profit to the industry unless the rate of fishing be controlled.* This may be illustrated by tracing the course of one of those improvements of working that bring profit to ordinary enterprizes. Let us suppose that Diesel engines prove cheaper to run than steam engines, so that Diesel ships make a better profit than steam ships. At first, there is prosperity for enterprising owners of vessels who adopt the new method. This would lead to replacement of more and more vessels, until all the fleets consist of Diesel ships. All would, *ex hypothesi*, show a profit. If the rate of fishing were controlled, there seems no reason why this happy state should not continue.

In ordinary commercial practice, however, we may expect further development. Everyone wants to joint in when there is a profit available and even those who are already in the industry are rarely content with what profit they have, but seek instead to increase it by expanding their activities. Unless this is deliberately prevented by some international arrangement, all past experience leads us to prophesy that the rate of fishing would, in these circumstances, eventually rise.

If, however, this rise takes place, equilibrium will be disturbed and the stock must be reduced to a lower point on the sigmoid curve. We may be sure that eventually the only limit to this process is the point at which the fishery is again on the whole unprofitable.

The principle has been illustrated by reference to a reduction of fuel costs. The same argument can be used to show the vulnerability of any other improvement, such as in markets, in transport, inventions of fishing gear or international regulation of mesh. The data which Dr. Russell has shown demonstrate what harm has been done by the Vigneron-Dahl trawl and other means for increasing the rate of fishing.

In the long run, *only temporary prosperity can be expected until there is some international arrangement to prevent the rate of fishing increasing.*

These conclusions may seem gloomy, but fishery scientists need not shoulder the unpopularity of those who bring only bad news. There is also very good news implicit in the modern formulation. If, by international agreement, there can be not merely control of the rate of fishing, but actual reduction, there is a fair enough prospect of better times for all. At first, on reduction of fishing, there would be a reduction of yield. But in the case of overfished stocks, there would later on be the *increased yield from this reduced effort.* This may be illustrated on the curve. If the stock is in equilibrium with fishing at the moment, then reduction of fishing will allow it to increase. If the stock at that time is represented by an ordinate below the point of inflexion on the sigmoid curve, the new yield will be greater than the old. But the consideration that should gladden the heart of the man with the account book is that *less money* will be spent to catch a yield that is no less, in fact a little greater. From the explanations that have been used by Dr. Russell, it will be realized that it is not a matter of profit in twenty or even ten years time, but in two, three or four years, when the fish that are now in the sea have time to grow a little more.

There can be no doubt that if there were some form of concerted reduction of the rate of fishing itself, there would be a remarkable return for the scientific labours of the last forty years. The success of the international effort in introducing mesh regulations, without which control of the rate of fishing would be impossible, may, perhaps, give some encouragement. Unfortunately, it may still be true that intelligent international co-operation is the exception rather than the rule. It is, however, equally true that opportunities for such co-operation come without warning. It seems elementary caution to be in a perpetual state of preparedness for this happy emergency; in fact, to have ready and up-to-date information as to what stocks of fish are over-fished. The present information is valuable and sufficient in the most marked examples, but it needs keeping up-to-date and extending. In particular, in some areas, we have to reckon with recent *apparent* reduction in fishing, which may be unreal or may be inconsiderable. We have also to gauge the effects of mesh regulations and size-limits.

The situation, as it is developing, seems to demand more information than we have at present; for now we can only detect marked cases of overfishing. For every fishery of commercial importance, we shall probably require a short series of numbers, each number being an estimate of the average value of one of the four rates, those of:— recruitment, growth, natural mortality and fishing. In making these estimates it will be fundamental to decide in advance what the population is for which the averages are calculated. Our information seems least adequate as to the rate of fishing, which can be derived from marking experiments and also, perhaps, by estimation of stock from the planktonic eggs taken in Hensen's net. Given up-to-date and adequate estimates of growth-rate, mortality and rate of fishing, we can at any time detect overfishing. If the fisheries are to continue, we may be sure that sooner or later the remedy for overfishing will be called for. We may all agree that it would be better sooner than later.

References in Bückmann, Ber. Deutsch. Wiss. Komm., 1938 and Graham, Nature, 1938.

3.

ZUR FRAGE DER BEZIEHUNGEN ZWISCHEN BEFISCHUNG UND ERTRAG.

EINIGE METHODOLOGISCHE FOLGERUNGEN AUS DEN DEUTSCHEN SCHOLLENUNTERSUCHUNGEN IN DER NORDSEE.

VON

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DIE vorstehenden Darlegungen E. S. Russells und Grahams zeigen klar, was wir unter "Überfischung" verstehen müssen: Den Zustand eines genutzten Fischbestandes, in dem der Gesamtertrag bei jeder weiteren Steigerung der Befischungsintensität zurückgeht.

Wir haben also das grösste Interesse daran festzustellen, ob bei dem unserer wissenschaftlichen Überwachung anvertrauten Fischbestand die Befischung bereits den optimalen Grad überschritten hat oder nicht. Zwei Wege, um zu einer Antwort auf diese Frage zu gelangen, hat Russell bereits gekennzeichnet. Ein dritter eröffnet sich uns, wenn wir über eine eingehende biologische Analyse des betreffenden Nutzfischbestandes und der Anlandungen verfügen. Wir wollen die Möglichkeiten und Schwierigkeiten der Wege einmal kurz erörtern.

1. Der empirisch-statistische Weg.

Den ersten Weg hat Russell in sehr eindrucksvoller Weise für den Schellfisch der Nordsee vorgeführt: Er hat gezeigt, dass die im Verlauf der Jahre erfolgte Steigerung der Befischungsintensität eine in der Anlandungsstatistik nachweisbare Abnahme der Erträge nach sich gezogen hat.

Einer solchen Feststellung wohnt natürlich eine grosse Beweiskraft inne. Wir sehen, dass die Vermehrung der Aufwendungen für den Fangbetrieb nur die Folge hat, den Ertrag zu verringern und können uns ausrechnen, dass die Wirtschaftlichkeit des einzelnen Betriebes noch viel mehr abnehmen muss. Wo wir dies nachweisen können, haben wir ein wirksames und klares Argument gegen die zu starke Befischung.

Unglücklicherweise bestehen häufig gewisse Schwierigkeiten bei der Ermittlung der Befischungsintensität sowohl wie des Ertrages. Dadurch wird die Beweisführung in manchen Fällen minder übersichtlich, im einzelnen wohl gar unsicher.

Es erschwert z. B. unsere Einsicht in die Verhältnisse sehr, dass ein wesentlicher Teil der Befischungsintensität in den letzten Jahrzehnten durch technische Verbesserung von Schiff und Gerät herbeigeführt ist. Dieser einmalige Mehraufwand, der vom Geiste bestritten wurde, ist nicht so fühlbar wie es laufender Mehraufwand von Betriebsstoff und Arbeitsleistung sein würde. Auch ist die Leistungssteigerung nicht leicht statistisch zu ermitteln. (Einen Versuch dazu verdanken wir Bowman, der die Fangkraft des Patentgeschirrs mit der des alten Fischdampfertrawls verglich, und Lundbeck, der einen Vergleich der Fangleistung (Fang je Fangtag) moderner und älterer Fischdampfer vornahm.)

Nicht geringere Schwierigkeiten bieten sich bei der Bestimmung des Ertrages. So lehrt z. B. die Erfahrung, dass bei abnehmender Bestandsdichte die Marktauslese, die die Fischer in See treffen, sich verändert. Es werden heute viele Fische als marktfähig gelandet, die früher zwar auch gefangen, aber als untermassig verworfen worden wären. Die Statistik misst daher sozusagen die Ertragsfähigkeit des ehemaligen und des heutigen Bestandes mit verschiedenerlei Mass. Für die Veränderung der Marktauslese legt die Einbürgerung neuer kleinerer Marktsorten in manchen Fällen Zeugnis ab. Die Möglichkeit, eine Korrektur für die Veränderung bei den Zahlen der Statistik anzubringen, haben wir aber nur, wenn wir über umfangreiche Marktmessungen verfügen. Es ist eine dringende Aufgabe für unsere praktischen Untersuchungen, uns jederzeit mit Angaben über die tatsächliche Grössenzusammensetzung der angelandeten Fische zu versehen.

Eine grössere Schwierigkeit bei der Auswertung der statistischen Daten über den Ertrag ist die folgende: Wir wissen, dass bei der Steigerung der Befischungsintensität der Ertrag vorübergehend zunimmt. Er umfasst nämlich zunächst ausser der natürlichen Vermehrung noch einen gewissen Teil des Bestandes selbst, denn dieser wird bei der Steigerung der Befischung verdünnt. Welcher Teil der Anlandungen auf diese Abfischung des Bestandes zurückzuführen ist, ist aus der Statistik nicht zu ersehen. Wir können nur sagen, dass dieser Fehler nach einer Reihe von Jahren verschwunden sein muss.

Die grösste Schwierigkeit aber dürfte in dem Einfluss liegen, den die Schwankungen in der Stärke der Nachwuchsjahrgänge auf die Anlandungsmenge haben. Will man die Grösse des Ertrages ermitteln, der einer bestimmten Befischungsintensität zugeordnet ist, so muss man, um die Wirkung der Fluktuationen auszugleichen, den Durchschnitt aus einer erheblichen Zahl von Jahren nehmen. Im allgemeinen dürfte aber die Befischungsintensität garnicht so lange gleich bleiben, wie es dazu nötig wäre. Überdenken wir z. B. die Geschichte des Schollenbestandes der südlichen Nordsee in den letzten Jahrzehnten, so finden wir,

dass im Abstand von wenigen Jahren Änderungen in Art und Stärke der Befischung eintraten. Wir haben die Kriegsschonzeit von 1915—18, die intensive Abfischung des angehäuften Bestandes vornehmlich durch Dampfer 1919—21, den Rückgang der Dampferfischerei in den folgenden Jahren, aber andererseits die Leistungssteigerung durch die Einführung des Patentgeschirrs 1926—28, die Ausdehnung der Kutterfischerei von etwa 1925 an, den Einfluss der Wirtschaftskrise von 1931, und endlich Ausbau und Einsatz der Flotten der holländischen und belgischen Motorschiffe mit ihren engmaschigen Schleppnetzen, die von 1935 an auch in der Deutschen Bucht erschienen.

Infolge dieser Schwierigkeiten liefert die empirisch-statistische Betrachtungsweise allerdings sehr beweiskräftige, aber nicht in allen Fällen eine klare Antwort auf unsere Frage nach den Beziehungen zwischen Befischung und Ertrag. Die Natur und die menschliche Wirtschaft bringen eben im Zusammenwirken kein sauberes Experiment zustande.

2. Der Weg der Berechnung auf biologischer Grundlage.

Diese Schwierigkeiten umgeht zumeist der zweite Weg. Man kann auf Grund genügender biologischer Kenntnisse die Ertragsfähigkeit eines Bestandes bei verschiedener Befischung durch Rechnung vergleichen. Ein sehr einfaches und darum einleuchtendes Beispiel einer solchen Berechnung hat Russell oben gegeben, und wir haben gesehen, dass wir im Ansatz der Rechnung von dem störenden Einfluss der Fluktuationen ganz absehen können.

Wir haben weiter gesehen, dass nach Ausschaltung der Fluktuationen die Grösse und Zusammensetzung des Bestandes im Wesentlichen durch die Befischungsintensität bestimmt wird, denn neben der Sterblichkeit durch Fischerei spielt die natürliche Sterblichkeit eine geringe Rolle.

Je nach Grösse und Zusammensetzung des Bestandes wird aber auch die Menge Fischfleisch verschieden sein, die durch das Wachstum der Individuen, die den Bestand zusammensetzen, insgesamt erzeugt wird. Dies "Bestandswachstum" ist ausschlaggebend für die Ertragsfähigkeit des Bestandes. Kennen wir also durch unsere Untersuchungen die Grösse und Zusammensetzung, die ein und derselbe Bestand unter dem Einfluss verschiedener Befischungsintensität angenommen hat, und kennen wir die individuelle Wachstumsgeschwindigkeit der Fische in verschiedenem Alter, so können wir das Bestandswachstum berechnen und damit näherungsweise einen Vergleich der Ertragsfähigkeit des Bestandes bei verschiedener Befischungsintensität ziehen. In methodisch wohldurchdachter Weise hat Graham 1935 und 1938 solche Berechnungen vorgenommen. Doch muss er, wie Russell bei der oben mitgeteilten elementaren Berechnung, zwei Hilfsannahmen machen, deren Berechtigung von Fall zu Fall geprüft werden muss: 1) Der Nachwuchsanfall soll bei der Veränderung der Befischungsintensität gleich bleiben. 2) Die individuelle Wachstumsgeschwindigkeit soll sich bei einer mässigen Änderung der Befischungsintensität nicht ändern. Diese Annahme erscheint bei Kabeljau und Schellfisch durchaus berechtigt. Bei der Scholle der südlichen Nordsee aber scheint sie mir unzulässig zu sein. Wir wissen ja, dass die Wachstumsgeschwindigkeit der Schollen hier innerhalb weiter Grenzen veränderlich ist. Fig. 1 zeigt die Schwankungen der Durchschnittslänge der Schollen bei Helgoland in lange Zeit hindurch fortgeführten Beobachtungsreihen (mit Unterbrechungen 1906—1938). Aus den Untersuchungen verschiedener Forscher wissen wir, dass die Wachstumsgeschwindigkeit der Schollen weitgehend von der Bevölkerungsdichte abhängig ist. Das dürfte auch in den Arbeiten von Schmidt, Kotthaus und dem Verfasser hinlänglich dargelegt sein. Unsere Fig. 2 gibt noch einmal eine Darstellung der Verhältnisse: Die Bevölkerung ist gekennzeichnet durch den Durchschnittsfang je Stunde mit dem Grundschleppnetz des "Poseidon" im Frühjahr in der ganzen Deutschen Bucht. Die Wachstumsgeschwindigkeit ist gekennzeichnet durch die Gewichtszunahme der Schollen der einzelnen Jahrgänge von einer Altersgruppe zur anderen (in g.). Die Kovariation fällt ohne weiteres auf. Da nun jede Änderung der Befischungsintensität eine adaequate Änderung der Bevölkerungsdichte zur Folge hat, so ist dabei mit einer Änderung der Wachstumsgeschwindigkeit absolut sicher zu rechnen.

Wiederum haben wir hier eine Aufgabe unserer praktischen Untersuchungen. Wir dürfen nicht dabei stehen bleiben, die Abhängigkeit zwischen Bevölkerungsdichte und individuellem Wachstum nachzuweisen, sondern wir müssen die Art dieser Beziehung so genau kennen lernen, dass wir die Wirkung einer gegebenen Bestandsänderung auf das Wachstum (*ceteris paribus*) vorausberechnen können. Wir müssen also das ermitteln, was der Verfasser bei seinen Erörterungen über die Wirkung der Vernichtung untermassiger Fische auf die Ertragsfähigkeit "das Wachstumsgesetz" genannt hat. Dazu sind allerdings noch erheblich mehr Unterlagen nötig als gegenwärtig zur Verfügung stehen.

So hat der Weg der Berechnung auf biologischer Grundlage den Vorzug grösserer Klarheit der Ergebnisse, doch leider auch den Nachteil geringerer Überzeugungskraft. Er muss vor der Hand mit einigen Hilfsannahmen arbeiten, deren Berechtigung nicht ohne weiteres angenommen werden kann.

Es kann kein Zweifel bestehen, dass wir beide Wege zu gehen versuchen müssen, und dass wir durch intensive praktische Untersuchungen die Unterlagen in beiden Fällen sehr verbessern können.

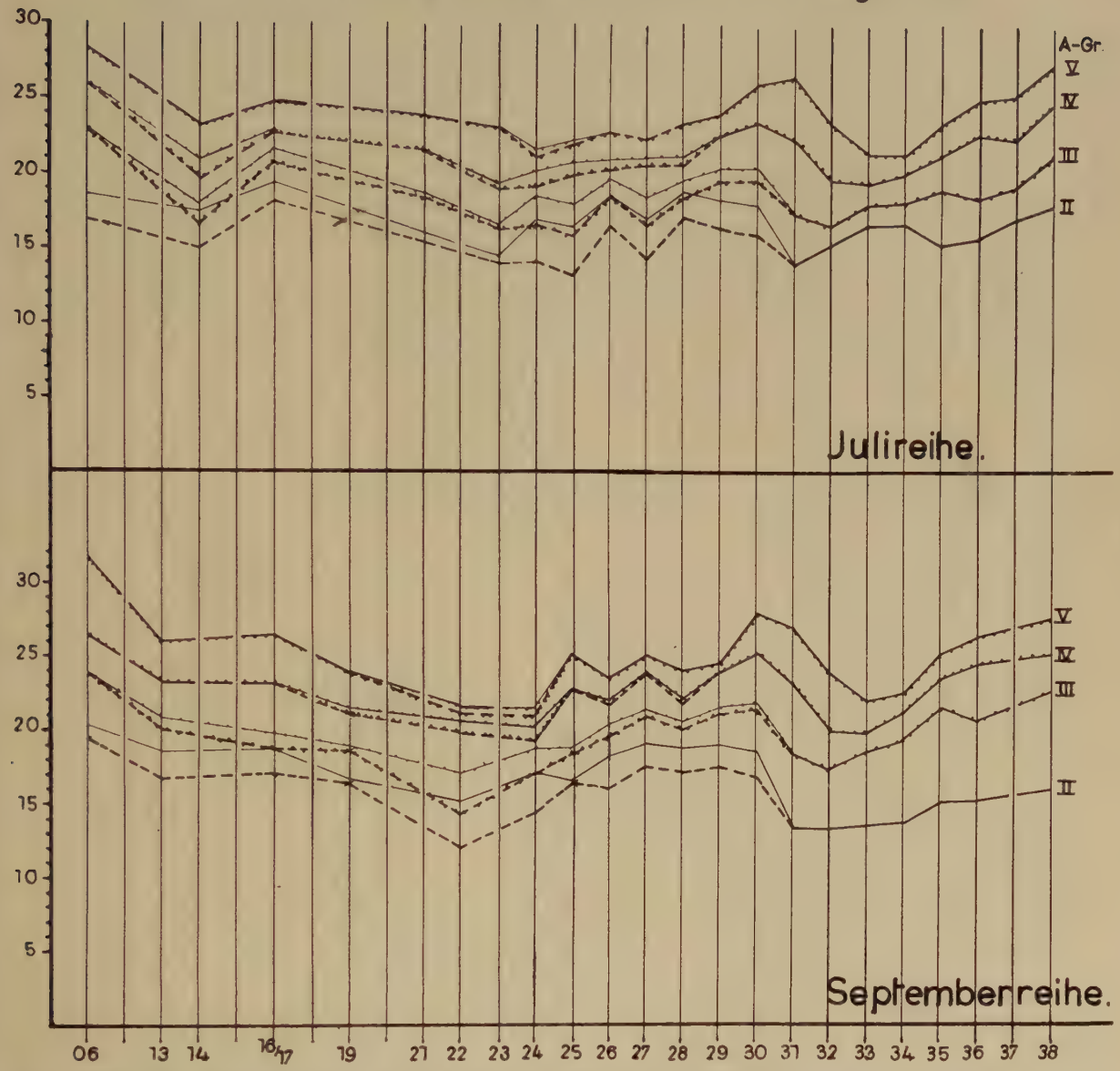


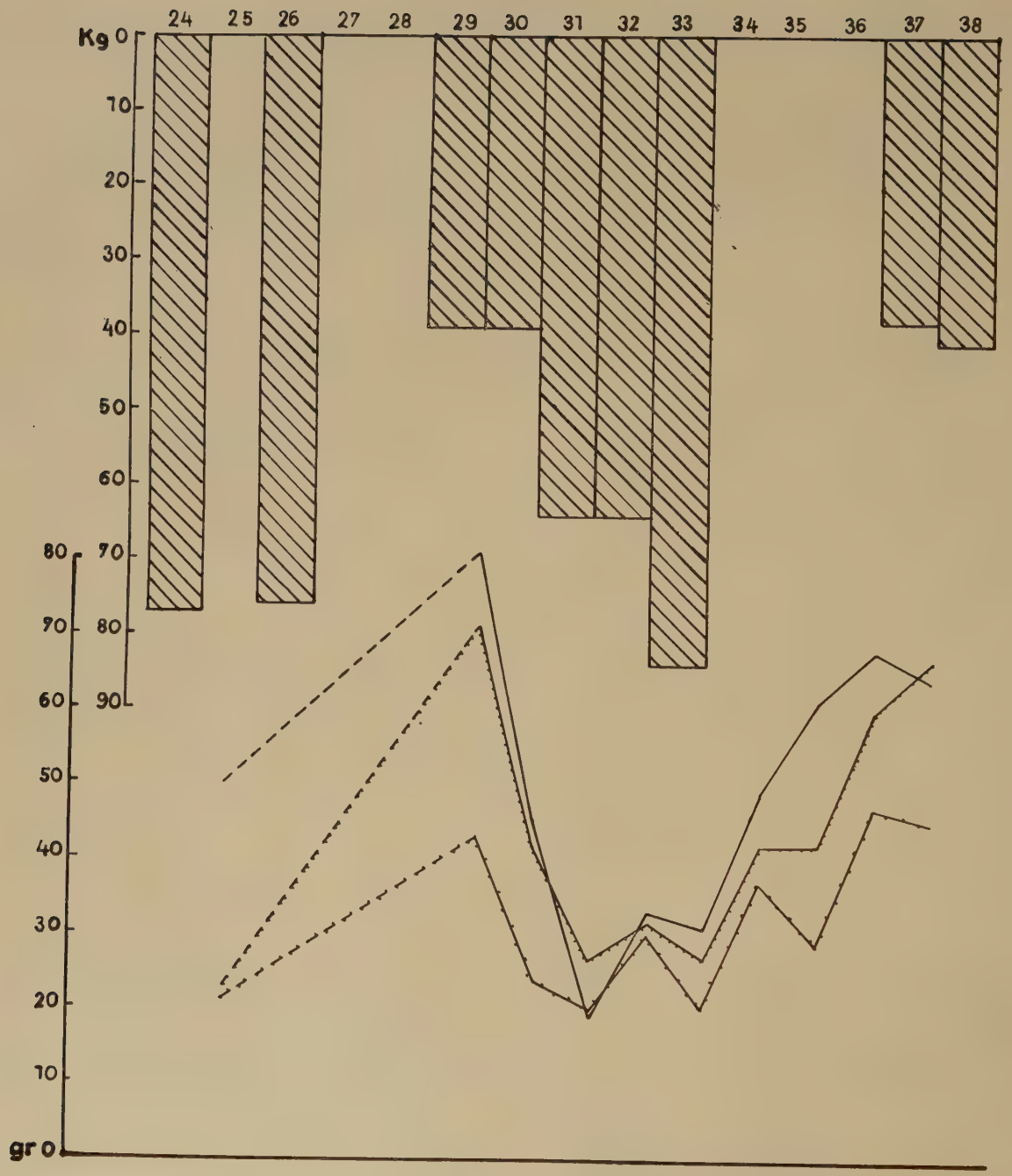
Fig. 1. 1931—1938 Durchschnittslängen in den Fängen des Decksteertnetzes; 1906—1930 Durchschnittslängen in den Fängen des Kutter- bezw. Dampfertrawls mit einfachem Steert (dünne Linien). Durchschnittslängen hieraus berechnet auf Grund der Vergleichsfänge für den Fang des Decksteertnetzes (fette Linien).

Wenn wir aber sehr umfangreiche Untersuchungen über den Nutzfischbestand in See und über die Anlandungen an den Fischmärkten zu diesem Zweck zu machen gezwungen sind, dann erschliesst sich uns auch ein neuer Weg, die Frage zu beantworten. Er hat den Vorzug, dass er wieder rein empirisch ist. Die Schwierigkeiten des statistischen Weges aber werden zum guten Teil ausgeschaltet, wenn wir durch biologische Analyse des Bestandes und der Anlandungen in die Lage versetzt werden, die Frage der Beziehung zwischen Befischungsintensität und Ertrag an jedem einzelnen Jahrgang zu prüfen. Wir wollen diese Möglichkeit, die sich für die Zukunft eröffnet, den

3. Weg der biologischen Analyse

nennen. Die deutschen Untersuchungen über die Scholle der Nordsee geben uns nach ihrer Anlage die Möglichkeit, diesen Weg zu zeigen, nicht jedoch bisher, ihn erfolgreich zu beschreiten.

Das bis heute vorliegende Beobachtungsmaterial



Dichte der Schollenbevölkerung der Deutschen Bucht und Wachstumsgeschwindigkeit.

(Gewicht des Durchschnittsfangs je Stunde)

Gewichtszunahme von Altersgruppe II–III —, Altersgruppe III–IV —, Altersgruppe IV–V — —.

Fig. 2.

ist nämlich leider noch nicht umfassend genug, um endgültige Schlüsse darauf zu gründen.

Das liegt einmal daran, dass unsere Arbeitsmöglichkeiten in gewissem Masse beschränkt waren. Die Grösse der untersuchten Proben steht daher in einem gewissen Missverhältnis zur Grösse der Bevölkerung und der Anlandungen, die sie repräsentieren sollen. Manche unserer bisherigen Ergebnisse sind daher auch noch mit einer fühlbaren Unsicherheit behaftet.

Weit schwerer aber wiegt für unsere Betrachtungsweise hier, dass die deutschen Untersuchungen nur einen Teil des Schollenbestandes der südlichen Nordsee, nämlich die Schollenbevölkerung der Deutschen Bucht, und nur einen sehr kleinen Teil der Anlandungen, nämlich die der deutschen Kutter, betreffen. Es werden allerdings in den an der Frage interessierten Ländern grossenteils ähnliche Untersuchungen durchgeführt. Wenn diese ganz gleichartig ausgestaltet und zusammengefasst würden, so wäre nach Ablauf einer Reihe von Jahren eine Beantwortung unserer Frage möglich. Vorerst soll uns die Darstellung der deutschen Untersuchungen nur dazu dienen zu zeigen, welch weitreichende Schlüsse durch eine straff organisierte internationale Zusammenarbeit möglich werden würden.

Über die Untersuchungen sind eine Anzahl von Mitteilungen von Lundbeck, Kotthaus, Schmidt und dem Verfasser erschienen, aus denen Einzelheiten entnommen werden können. Die Arbeiten bestehen aus zwei Teilen: aus der Überwachung der Schollenbevölkerung der südöstlichen Nordsee durch periodische Forschungsfahrten in See und aus der Überwachung der Anlandungen durch Untersuchung von Stichproben an den Fischmärkten und statistischen Erhebungen.

(a) Die Aufgabe der Seeuntersuchungen ist es, alljährlich einmal den Durchschnittsfang an Schollen je Stunde und seine Zusammensetzung aus Altersgruppen zu bestimmen. Der Durchschnittsfang soll in einer solchen Weise ermittelt werden, dass er ein Mass für die Dichte der ganzen Schollenbevölkerung und der einzelnen Altersgruppen im Bereich der Deutschen Bucht von Borkum Riff bis Horns Riff abgibt. Durch unsere Frühjahrsuntersuchungen auf einem verhältnismässig engen Stationsnetz wird dies Ziel befriedigend erreicht.

Auf dieser Grundlage kann man zunächst die Stärke der einzelnen Jahrgänge in ihrem Verhältnis zueinander zahlenmässig recht gut abschätzen. Man vergleicht in erster Linie den durchschnittlichen Stundenfang im Alter von 2 Jahren. Allerdings ergeben sich einige Schwierigkeiten aus den Schwankungen der Wachstumsgeschwindigkeit, die aber durch den Vergleich der Häufigkeit in höherem Alter einigermassen behoben werden können.

Wir schätzen das Stärkeverhältnis der Schollenjahrgänge in der Deutschen Bucht auf Grund unseres Materials wie folgt: —

Jahrgang:	1922	1923	1924	1925	1926	1927	1928
	85	25	20	50	25	35	100
1929	1930	1931	1932	1933	1934	1935	1936
32	22	18	25	36	46	50	46

Diese Daten haben nicht allgemeine Gültigkeit für den Schollenbestand der südöstlichen Nordsee, weil ganz abgesehen von gewissen Mängeln des deutschen Materials die Verhältnisse in der südwestlichen Nordsee und vor der jütischen Küste nicht gebührend berücksichtigt sind. Aus früheren Vergleichen wissen wir, dass der Ausfall der Jahrgänge bisweilen in benachbarten Gebieten recht verschieden sein kann. Eine Kombination der Befunde in allen diesen Gebieten wäre also anzustreben.

Das gleiche Material soll uns aber auch die Grundlage für die Bestimmung der Befischungsintensität liefern. Ein gewisses Mass für dieselbe erhalten wir, wenn wir die Abnahme der einzelnen Jahrgänge von einem Jahr zum anderen verfolgen, wie sie ja im Durchschnittsfang messbar nachgewiesen wird.

Allerdings ist ja diese Abnahme nicht ausschliesslich auf die Befischung zurückzuführen. Vielmehr wird die Zahl der Schollen auch durch natürliche Sterblichkeit verringert. Soviel wir wissen, ist diese aber von viel geringerem Umfang als die Sterblichkeit durch Fischerei. Sie fällt gerade bei der Scholle garnicht wesentlich ins Gewicht. Vor allem aber können wir eine systematische Änderung in der Abnahme der Schollenzahl, etwa eine Beschleunigung, mit Sicherheit auf eine Änderung in der Sterblichkeit durch Fischerei, also in der Befischung, zurückführen.

Bei den hier zugrundeliegenden deutschen Untersuchungen aber bringt die räumliche Begrenzung eine weitere Fehlerquelle mit sich. Innerhalb unseres Untersuchungsgebietes umfasst die Abnahme der Individuenzahl eines Jahrgangs von einem Jahr zum anderen nicht nur die gesamte Sterblichkeit, sondern auch den Verlust durch Abwanderung nach den mittleren Gründen der Nordsee. Diese Fehlerquelle ist deshalb besonders störend, weil das Mass der Abwanderung schwankt: sie setzt bei schnellwüchsigen Jahrgängen früher ein als bei langsamwüchsigen. Um diese Fehlerquelle auszuschalten, müsste man die Bestandsaufnahme auf die mittleren Gründe der Nordsee ausdehnen, was eine sehr erhebliche Mehrarbeit bedeutet, oder man müsste die Abnahme der Individuenzahl der Jahrgänge im Durchschnittsfang der praktischen Fischerei bestimmen und zur Korrektur der bei den Seeuntersuchungen gefundenen verwenden. Dies ist möglich, wenn die Altersuntersuchungen der Anlandungen, von denen unten die Rede sein wird, durchgeführt werden und der Durchschnittsfang bestimmter Fahrzeug-Typen (etwa Durchschnittsfang englischer Dampftrawler je 100

Stunden, vergl. Graham, 1938) aus der allgemeinen Statistik entnommen werden kann.

Gegenwärtig verfügen wir über derartiges Material noch nicht. Wir werden vorsichtshalber die Abnahme der Zahl hier nur bei solchen Jahrgängen vergleichen, die etwa gleiche Wachstumsgeschwindigkeit haben. Wir dürfen dann annehmen, dass die Abwanderung aus unserem Untersuchungsgebiet bei ihnen auch in ähnlicher Weise erfolgt und mithin die Abnahme der Individuenzahl in ähnlicher Weise beeinflusst.

Wegen einer Lücke in unseren Beobachtungen (von 1934 bis 36) können wir noch nicht die Abnahme der Individuenzahl einer grösseren Anzahl von Jahrgängen gleicher Wachstumsgeschwindigkeit durch mehrere Altersgruppen verfolgen. Wir haben folgende Werte zur Verfügung:—

beim Jahrgang		Abnahme zwischen den Altersgruppen II u. III	III u. IV	IV u. V
1925	%	?	?	81
1926	%	?	58	54
1927	%	26	23	62
1933	%	?	?	85
1934	%	?	76	?
1935	%	20	?	?

Legt man selbst die höchsten Werte zugrunde, die bei den Jahrgängen 1925/27 vorkommen (es sind die Abnahmen von 1929 auf 1930), so würden von 1000 Schollen im Alter von 2 Jahren noch 59 fünfjährige am Leben gewesen sein. Bei den Verhältnissen aber, wie sie 1937/38 herrschten, blieben von 1000 zweijährigen nur 29 fünfjährige über.

Trotz aller methodischen Schwierigkeiten haben wir hier einen Beleg für die Steigerung der Befischungsintensität in den letzten Jahren, und wir erkennen, dass bei Ausdehnung der Untersuchungen und enger internationaler Zusammenarbeit eine vollkommen verlässliche Bestimmung der Veränderungen der Befischungsintensität auf dem hier vorgeschlagenen Weg möglich ist.

Vielleicht ist eine Erklärung angebracht, weshalb nicht ein anderer Weg zur Bestimmung der Befischungsintensität gegangen wird. Wir haben hier das statistische Verfahren, das im allgemeinen den Zeitaufwand, den die Fahrzeuge der einzelnen Typen für den Fang brauchen, feststellt. Die Statistik kann aber nicht nachweisen, welche Wirkung die Fischerei tatsächlich auf den einzelnen Fischbestand hat: diese kann bei gleichem Zeitaufwand je nach Art des Geräts, nach Lage der Fangplätze etc. vollkommen verschieden sein.

Die Ergebnisse der Markierungsexperimente zeigen allerdings unmittelbar die Wirkung der Fischerei auf den Schollenbestand in dem Prozentsatz der Wiederfänge. Sie können aus praktischen Gründen aber kaum in solchem Umfang ausgeführt werden, dass sie laufend ein brauchbares Mass der Befischungsintensität lieferten. Vor allem aber geben sie keine zuverlässige Antwort auf die Frage, welcher Befischungsintensität die untermassigen Fische ausgesetzt sind. Denn es bleibt allzusehr dem Zufall überlassen, ob eine markierte und wiedergefangene untermassige Scholle vom Fischer bemerkt wird oder nicht. Gerade die Zehrung bei den untermassigen Fischen aber spielt eine grosse, wonicht die ausschlaggebende Rolle für die Ertragsfähigkeit des Bestandes. So sind die übrigen sich bietenden Verfahren zur Bestimmung der Befischungsintensität dem hier vorgeschlagenen nicht vorzuziehen. Es ist im Gegenteil für unsere Betrachtung sehr wichtig, dass wir die Sterblichkeit bei jedem einzelnen Jahrgang für sich berechnen können. Unsere Aufgabe ist es nur, die Fehlerquellen so gut wie möglich auszuschalten.

(b) Die deutschen Marktuntersuchungen sind so aufgezogen, dass wir die Alterszusammensetzung der Gesamtanlandung in erster Annäherung berechnen können. Auch hier ist aber eine Verbesserung der Unterlagen möglich — z. B. Ergänzung der Altersproben durch ausgedehntere Messungen — und z. T. auch nötig.

Bei diesen seit 1930 laufend ausgeführten Untersuchungen sehen wir immer neue Schollenjahrgänge in den Anlandungen erscheinen, ihren Beitrag dazu liefern und wieder verschwinden, wenn im Alter von 8 oder 9 Jahren nur noch spärliche Reste von ihnen im Arbeitsgebiet der deutschen Kutterflotte zurückgeblieben sind. So tritt der Jahrgang 1928 zum ersten Male mit einer geringen Anzahl von Individuen im Alter von 2 Jahren in den Anlandungen des Jahres 1930 auf. In den folgenden Jahren nimmt die Zahl der gelandeten Fische dieses Jahrgangs schnell zu und erreicht im Jahre 1933 mit fast 15 Millionen Stück fünfjähriger Fische ihren Höhepunkt. Von da an nimmt die jährliche Anlandungsmenge ab, bis 1937 nur noch 0·16 Millionen Stück nunmehr neunjähriger Fische gelandet wurden.

Üblicherweise wird die Grösse und Zusammensetzung der Anlandungen eines Kalenderjahres dargestellt. Unsere Fig. 3 dagegen fasst die Erträge zusammen, die jeder einzelne Jahrgang nach und nach zu den Anlandungen beigetragen hat; für jeden Jahrgang ist ein Rechteck entsprechender Grösse gezeichnet (Masstab links). Bei dem Jahrgang 1928 z. B. sind es insgesamt 36 Millionen Stück, die sich auf die Fangjahre 1930—37 verteilen. Die Ausbeuten in verschiedenem Alter sind durch verschiedene Schraffur gekennzeichnet. — Für unsere Zwecke wäre es an sich wünschenswert, die Fangmenge nicht nach Stückzahl, sondern nach Gewicht anzugeben. Dies wäre möglich, wenn wir genügend Angaben über die Grössenzusammensetzung der Schollen jedes Alters hätten. Da diese aber in dem vorliegenden deutschen Material nicht ausreichen, musste die Umrechnung auf Gewicht unterbleiben. Es genügt festzustellen, dass die Gewichtsberechnung an sich durchführbar ist.

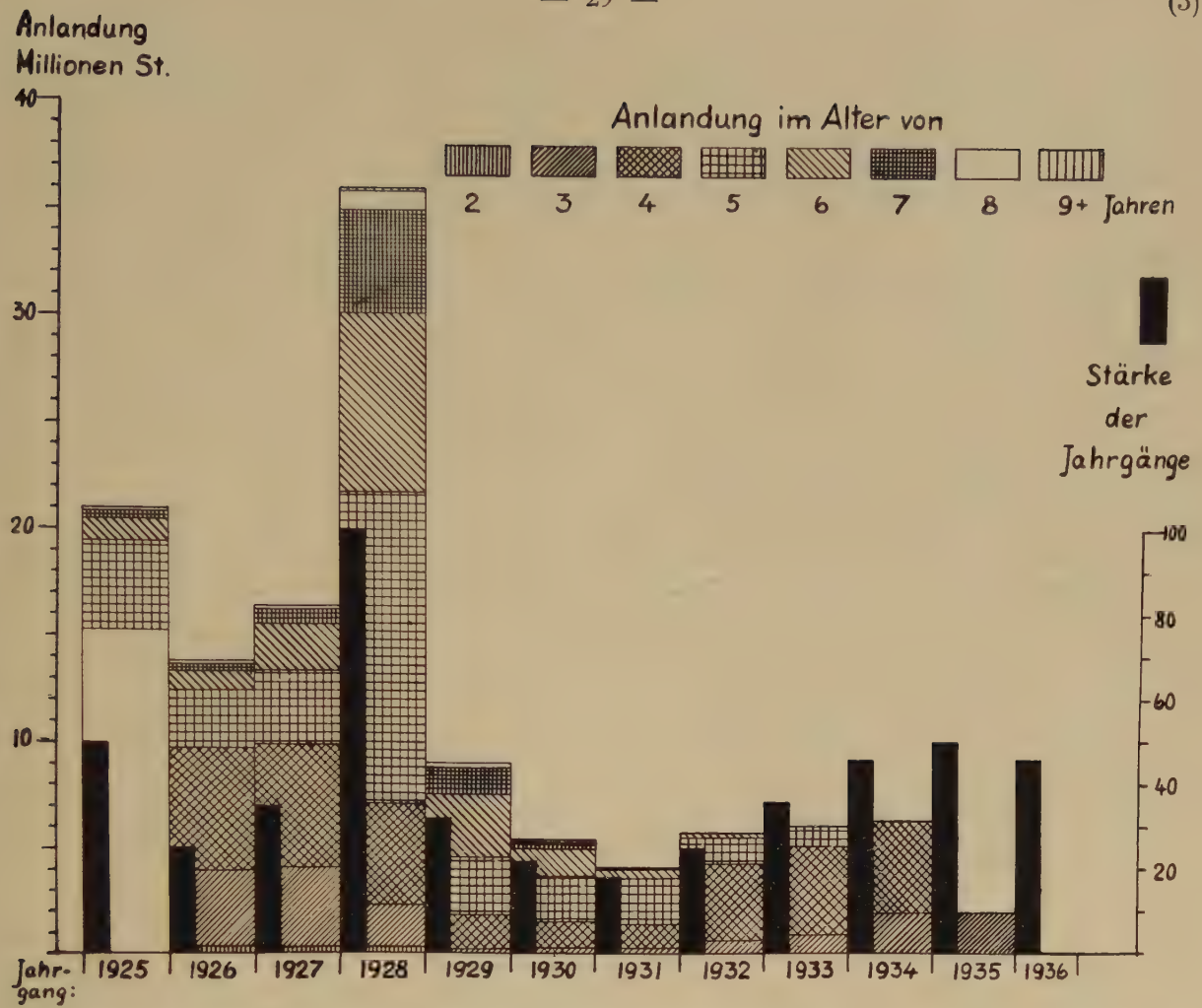


Fig. 3. Schollen der südöstlichen Nordsee. Stärke der Jahrgänge (schwarze Säulen) und Stückzahl in den Anlandungen der deutschen Hochseekutter (schraffierte Säulen).

Wir sehen an unserer Figur, dass die fischereiliche Ausnutzung der einzelnen Jahrgänge durch unsere Kutter etwas verschieden war. Der Jahrgang 1926 lieferte seinen höchsten Ertrag im Alter von 4 Jahren, den zweithöchsten im Alter von 3 Jahren, abermals weniger im Alter von 5 Jahren. In höherem Alter sind die Ausbeuten dann schon ganz unerheblich. Die Ausnutzung des Jahrgangs 1927 verlief ähnlich, aber die Ausbeute im Alter von 5 und 6 Jahren war doch wesentlich grösser. Der Jahrgang 1928 lieferte im Alter von 3 und 4 Jahren verhältnismässig kleine Ausbeuten, aussergewöhnlich hohe dagegen im Alter von 5 Jahren und, in abnehmendem Grade, auch noch mit 6 und 7 Jahren. Beim Jahrgang 1929 was es sogar so, dass er mit 3 Jahren ganz wenig und mit 6 noch etwas mehr als mit 5 Jahren erbrachte. Bei den Jahrgängen 1930 und 31 liegt der Höhepunkt der Ausbeute im Alter von 5 Jahren. Beim Jahrgang 1931 ist schon die Ausbeute im Alter von 6 Jahren ganz gering. Bei den folgenden Jahrgängen ist dann die höchste Ausbeute wieder im Alter von 4 Jahren zu verzeichnen, und beim Jahrgang 1934 ist auch die III-Gruppe schon wieder bedeutsam.

Diese Veränderung der Nutzung steht, wie wir wissen, mit den Schwankungen der Wachstumsgeschwindigkeit in Verbindung. Die Jahrgänge 1928—1931 waren im Alter von 4 Jahren im Durchschnitt noch so klein, dass nur ein geringer Teil von ihnen marktfähig war. Das Wachstum der gegenwärtig befischten Jahrgänge aber ist wieder etwa eben so gross wie das der Jahrgänge 1926 und 1927. Bei schnellwüchsigen Jahrgängen setzt die fischereiliche Nutzung früher ein, sie sind aber auch früher erschöpft als langsamwüchsige. Wir dürfen demnach nicht erwarten, dass die Jahrgänge 1933 und 1934 in Zukunft — im Alter von

6 und mehr bzw. im Alter von 5 und mehr Jahren — noch so grosse Ausbeuten liefern, dass ihr Gesamtertrag dadurch ausschlaggebend vergrössert wird. Man kann vielmehr die Endsumme, die sie liefern werden, jetzt bereits ungefähr absehen.

Unsere Figur 3 zeigt ausser der Ausbeute, die die einzelnen Jahrgänge geliefert haben, auch ihre relative Stärke, wie wir sie bei den Seeuntersuchungen gefunden haben. Diese Anfangsstärke wird durch die Länge des schwarzen Rechtecks (Masstab rechts) gekennzeichnet, das in das schraffierte Rechteck der Ausbeute für jeden Jahrgang hineingezeichnet ist.

Ziehen wir das in Betracht, was wir über die Aussichten auf die Ausbeute der jetzt befischten Jahrgänge oben festgestellt haben, so finden wir, dass die Ausbeuten der Jahrgänge im Verhältnis zu ihrer Anfangsstärke in letzter Zeit wesentlich geringer waren als bei den Jahrgängen 1925—1928. Man vergleiche die Höhe der schwarzen Säule mit der der zugehörigen schraffierten. Beim Jahrgang 1926 ist letztere reichlich doppelt so hoch, beim Jahrgang 1931 nur unwesentlich höher, beim Jahrgang 1933 wird sie voraussichtlich gar hinter der schwarzen zurückbleiben.

Wir finden das bestätigt, wenn wir die Ausbeuten der etwa gleich starken Jahrgänge 1926 und 1932, 1927 und 1933 vergleichen. Absichtlich haben wir wiederum, um eine Fehlerquelle zu vermeiden, Jahrgänge gewählt, deren Wachstumsgeschwindigkeit auch ungefähr gleich ist:

Ausbeute an Schollen
(in Mill. Stück).

Alter, Jahre	Jahrgang 1926	1932	1927	1933
3	3·7	0·6	3·8	0·8
4	5·8	3·5	5·8	4·2
5	2·7	1·4	3·5	1·2
6	0·9	0·3	—	—

Wir verzeichnen also hier ganz einwandfrei und unwiderlegbar einen Rückgang des Ertrages, den der Schollenbestand der südöstlichen Nordsee der deutschen Kutterfischerei liefert. Dieser Rückgang ist nicht auf eine Abnahme der Fischerei selbst zurückzuführen. Die Leistungsfähigkeit der Flotte ist vielmehr in letzter Zeit gestiegen. Wir brauchen aber auf diese Frage garnicht näher einzugehen. Denn wenn auch die Ausbeute, die die deutsche Kutterflotte aus dem Schollenbestand zieht, wie wir gesehen haben, infolge der gesteigerten Befischungsintensität gesunken ist, so ist dies doch noch nicht die endgültige Antwort auf die Frage, ob im ganzen genommen die vermehrte Befischung zu einer Abnahme des Ertrages geführt hat. Es wäre ja möglich, dass der Minderertrag bei der deutschen Fischerei durch einen Mehrertrag bei anderen Fischereien, etwa der holländischen und belgischen, ausgeglichen oder gar überwogen würde. Wir müssen also die Anlandungen aller für die Schollenfischerei wichtigen Länder nach Menge und Zusammensetzung so genau kennen, dass wir die gesamte Ausbeute, die die einzelnen Jahrgänge liefern, berechnen können.

Finden wir dann, dass der schneller abgefischte Jahrgang geringeren Ertrag liefert als ein gleich starker, der mit geringerer Intensität befischt wurde, dann haben wir einen einwandfreien empirischen Beweis dafür, dass der optimale Grad der Befischung bei unserm Bestand überschritten war[1]).

Wir haben im Vorstehenden gesehen, dass eine eingehende und umfassende biologische Analyse eines Nutzfischbestandes und der gesamten aus ihm gezogenen Anlandungen uns in die Lage versetzt zu beurteilen, ob wir bei weiterer Steigerung der Befischungsintensität die Erträge nur künstlich verkleinern würden oder nicht. Die Bestandsuntersuchungen müssen es gestatten, die Stärke der einzelnen Jahrgänge zahlenmässig zu charakterisieren und zu verfolgen, wie ihre Individuenzahl von Jahr zu Jahr abnimmt. Die Überwachung der Anlandungen muss es gestatten, die Ausbeute, tunlichst nach Gewicht, zu berechnen, die die einzelnen Jahrgänge insgesamt der Fischerei liefern. Verrät dann die schnellere Abnahme in der Individuenzahl der Jahrgänge eine Steigerung der Befischungsintensität, so ist zu prüfen, ob die Jahrgänge nach wie vor eine ihrer Stärke entsprechende Ausbeute liefern oder vielmehr eine geringere. Im zweiten Falle besteht eine Überfischung des Bestandes und Massnahmen zur Einschränkung der Fischerei müssen getroffen werden.

Bei der Scholle bringen, wie wir oben immer wieder gesehen haben, die starken Wachstumsschwankungen eine Erschwerung der Untersuchungen mit sich. Das hier geschilderte Verfahren würde vielleicht mit noch grösserem Erfolg bei einer Fischart angewendet werden, deren Wachstum so starke Schwankungen nicht aufweist, bei der aber die Altersbestimmung eben so leicht durchzuführen ist wie bei der Scholle.

Eine gewisse Schwäche der Methode liegt darin, dass die statistischen Fehler bei der Bestimmung der Stärke der Jahrgänge, der Zusammensetzung der Anlandungen und vor allem bei der Berechnung der Abnahme der Individuenzahl ziemlich gross werden. Durch vermehrte Untersuchungen und enge internationale Zusammenarbeit können aber diese Fehler verkleinert werden. Es steht dahin, was im gegenwärtigen Augenblick zur Durchführung einer derartigen Untersuchung wirklich geschehen kann. Wesentlich ist vor allem, dass der Kleinarbeit der Fischereiforschung hier ein Ziel gezeigt wird, das des Schweisses der Edelen wert ist.

[1]) Dies trifft allerdings nur unter der Voraussetzung zu, dass nicht die Nachwuchserzeugung infolge der stärkeren Befischung steigt. Dies ist sehr unwahrscheinlich, und man würde es bei den vorgeschlagenen Seeuntersuchungen auch feststellen können.

4.

AN IMPROVED METHOD OF SAMPLING HERRING SHOALS.

BY

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AT the beginning of an investigation into the composition of a stock of herrings, the most obvious method of sampling the shoals is to examine batches of fish taken at random from the drifters which catch the fish.

The number of individuals in each random sample required to represent all the age-groups in the shoals depends on the number of groups and the range of size of the fish, and can only be found by experiment. In the case of the East Anglian herring fishery, random samples each consisting of 100 fish have been found to show the main characteristics of the shoals, which usually are made up of not more than seven age-groups, and in which the range of size of the herrings is restricted to 8 or 9 cm.

During 1922, when the East Anglian investigations began, and the seven years which followed, this method of examining fish from the drifters was used, and the practice of taking four samples of herrings each week became established. The age and length of the individuals were found, and at the end of the season, which extended over about nine weeks, the thirty-six batches of data were added together and the total age and length distributions were assumed to be a true picture of the composition of the landings as a whole.

This original method showed up all the main characteristics of the fishery. It demonstrated quite clearly that the stock was made up of year-classes which varied in age from three to ten or eleven years, and also that certain of these groups contained enormous numbers of individuals while others contained comparatively few. By examining the data collected in October and November separately, it was discovered that the young herring. — the three and four-year-old fish which were developing in readiness for their first spawning, — entered the shoals during the early part of the season, and that the older age-groups gradually displaced the young ones in the later period, that is, some time in November.

The stock was thus naturally divided into two components which became known as the "recruit spawners" and the "old stock", and then, about 1929, when this composition became more fully understood, the following question suggested itself; "Is the proportion of young stock to old stock, as shown by the existing data, a true one?"

A cursory examination of the details of the data, together with the knowledge gained on the herring markets, suggested that there were many possible sources of error in the collection of the data which could make the answer to the above query an emphatic "No".

First of all the method of relying on four samples each week was in itself risky, for, in the event of a period of bad weather in November, (which is not at all uncommon in this area) there was a possibility that four samples in any one week would not be forthcoming, so that in the total of the data the proportion of old fish would be lower than would have been the case had all the samples been obtained.

Next, the drifters themselves caught different sizes of fish even on the same day. It was found that some vessels landed a majority of small herrings, some a majority of large, and others a mixed catch of small and large, so that the characteristics of the shoals as shown by the collected data depended on the drifters from which the samples were obtained. These errors could have been introduced by differences in the size of the mesh of the drift-nets as used by different ships, or by the uneven distribution of the various sizes of herrings over the area as a whole.

In view of these discrepancies, then, it could be said that the sampling up to 1929 was qualitative rather than quantitative, and the publishing of the first herring fishery forecast in that year caused the errors in sampling to be fully realized. If future forecasts were to be really worth while the composition of the herring stock must be known more accurately, so an attempt was made to define more clearly the relationship between the young and the old herrings in order that a reliable mortality rate might be calculated.

In 1930 the original method of sampling was reviewed, and the following procedure was designed to obliterate to a large extent the effect of the more obvious errors in the collection of the data.

It was, first of all, decided to measure as many fish as possible each day on the markets at Yarmouth and Lowestoft, so two assistants were employed — one at each of these two ports — during the whole of the herring season.

They obtained fish for measurement wherever possible; in curing yards, kippering houses or from

exporters of fresh herrings, and in this way, their total number of measurements at the end of a week represented the main mass of fish as landed, and the effects of "patchiness" on the fishing grounds and differences in "mesh" were removed, or, at any rate, considerably reduced.

At the same time, the four samples from the drifters which originally made up the main weekly sample were examined as usual at the laboratory but now the data resulting from this examination were used to find the age of the main bulk of herrings measured on the markets. This was done in this way: the age and length data from the four samples were arranged to show the age-distribution of each centimetre length-group, as in the example shown in Table I.

Table I.

Combined Samples: Length—Age-group Distribution:—

Length cm.	Age-Groups									Totals
	3	4	5	6	7	8	9	10	10+	
19	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—
21	1	—	—	—	—	—	—	—	—	1
22	8	1	—	—	—	—	—	—	—	9
23	24	17	—	—	—	—	—	—	—	41
24	22	47	12	1	—	—	—	—	—	82
25	5	45	56	14	1	1	—	—	—	122
26	—	9	36	21	13	3	1	—	—	83
27	—	2	5	10	7	9	7	4	1	45
28	1	1	—	3	2	3	5	2	—	17
29	—	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—	—	—	—
Totals	61	122	109	49	23	16	13	6	1	400

Next, the number of herrings in each centimetre length-group was found for each port separately every week, and the data arranged as in Table II (Measurer's Totals).

Now, the fish in each centimetre group in the "measurer's totals" of this table were arranged in age-groups in the same proportion as in Table I. For example, in the latter table, the fish which were 23 cm. long are divided into age-groups 3 and 4 in the proportion of 24:17, so the 256 fish of the same length in Table II must also be divided between age-groups 3 and 4 in this proportion, that is 150 and 106. This is done for each length-group until all the fish measured have been divided into age-groups.

The 21 herrings in Table II which were 29 cm. long presented a small difficulty as there were no fish of this length in the samples examined at the laboratory (Table I.). In such cases which occur quite frequently the large fish are distributed evenly throughout the oldest year-groups, and as they appear in small numbers only such "adjustment" does not materially affect the totals.

When the fishing season ended the total length and age-distributions had to be found but before the weekly totals were added together, the *percentage* length or age frequencies were "weighted" according to the quantities of fish landed each week.

This was done by multiplying each percentage distribution by a factor representing the number of crans landed each week at each port and then these raised totals were added together to give a grand total distribution for the season at both ports.

The percentage distribution of this grand total was then taken as representing the landings from the whole fishery from October to December.

Table II.

Length cm.	Age Analysis									Measurer's Totals	
	3	4	5	6	7	8	9	10	10+	No.	%
19	—	—	—	—	—	—	—	—	—	—	
20	—	—	—	—	—	—	—	—	—	—	
21	10	—	—	—	—	—	—	—	—	10	
22	74	9	—	—	—	—	—	—	—	83	
23	150	106	—	—	—	—	—	—	—	256	
24	174	373	95	8	—	—	—	—	—	650	
25	37	329	409	102	7	7	—	—	—	891	
26	—	68	271	158	98	23	7	—	—	625	
27	—	14	35	69	49	63	49	28	7	314	
28	7	7	—	20	13	20	33	13	—	113	
29	—	—	—	—	—	6	7	8	—	21	
30	—	—	—	—	—	—	—	—	—	—	
31	—	—	—	—	—	—	—	—	—	—	
Calculated Totals	452	906	810	357	167	119	96	49	7	2963	

This revised method was undoubtedly an improvement on the original and it was employed as a standard method until 1934 but, although the errors in sampling were corrected, the final results were still in the form of percentage frequency distributions. The proportion of young fish to old in any one year was probably quite accurate, but it was impossible to find the actual variation in the numerical strength of the individual year-groups between one year and another.

In 1935 a further change was made in the method of sampling and the routine observations which are now carried out make the calculation of the approximate numerical strength of each age-group an easy matter.

As in the previous method the market measurements were still looked on as indispensible and the four samples each week were still used to supply the age data required to divide the fish measured on the markets into age-groups.

The only additional work necessary was the finding of the weight of the fish of each age from three to ten years.

This was done in the following way: when each sample of 100 herrings was being examined at the laboratory the individual fish, after being measured and "scaled", were laid out on a bench in order from 1 to 100 so that it was possible to identify each fish. The scales, mounted on glass in the usual way, were dried and then examined as soon as possible, and when the age of each fish was found, the herrings were sorted into heaps according to age. Each heap of fish was then weighed to the nearest half-ounce and the weights and numbers of fish were entered on a form similar to that shown in Table III.

Table III.

Age	No.	lbs.	Oz.
3	3	—	10
4	28	7	7½
5	19	6	6½
6	23	7	12
7	5	1	10
8	8	3	1½
9	11	4	2
10+	3	1	2

At the end of the period of observation the data on all the forms were added together and the average weights of the individual fish of each age were found.

For the final calculation of the age-distribution in the total catch at Yarmouth and Lowestoft the form shown in Table IV was used.

The production of the "Calculated Totals" (a) has already been described. The "Factor" (b) is the average weight, in ounces, of herrings of each age, so, if all the totals in (a) are multiplied by the corresponding factor in (b) the column (c) will show the weights in ounces of the fish of each age in the total weekly sample measured on the market. The total weekly landing (d) is obtained from the statistical office on the market, in this case, 19,297 crans.

The "cran" is a volumetric measure and is converted to hundredweights (cwt.) by multiplying by the factor 3·75, thus the total weekly landing was 72,363·75 cwt.

Column (e), the weekly landing in cwt., is calculated by dividing 72,363·75 cwt. into the proportions shown in column (c), and in practice these latter calculations are carried out on a calculating machine, using the relative reciprocals.

Next, these total weights of the various age-groups are converted from hundredweights to ounces (f), and then, by dividing the latter by the weights of the individual herrings at each age (g) the estimated number of fish (in thousands) in each age-group is found for the week, so in the example it was found that approximately 25,287,000 herrings were landed at Yarmouth during the week ending 9th October, 1937 and of these, 3,857,000 were three years old and 60,000 were over ten years.

At the end of the season these "final" columns on all the weekly sheets for Lowestoft and Yarmouth are added together and the grand total for the whole fishing is obtained without further correction.

Some Results of the Sampling.

Since a discussion of the biological and statistical problems connected with the East Anglian herring fishery would be out of place in a paper such as this, it will suffice to show a few of the results of the sampling of the shoals, without much comment.

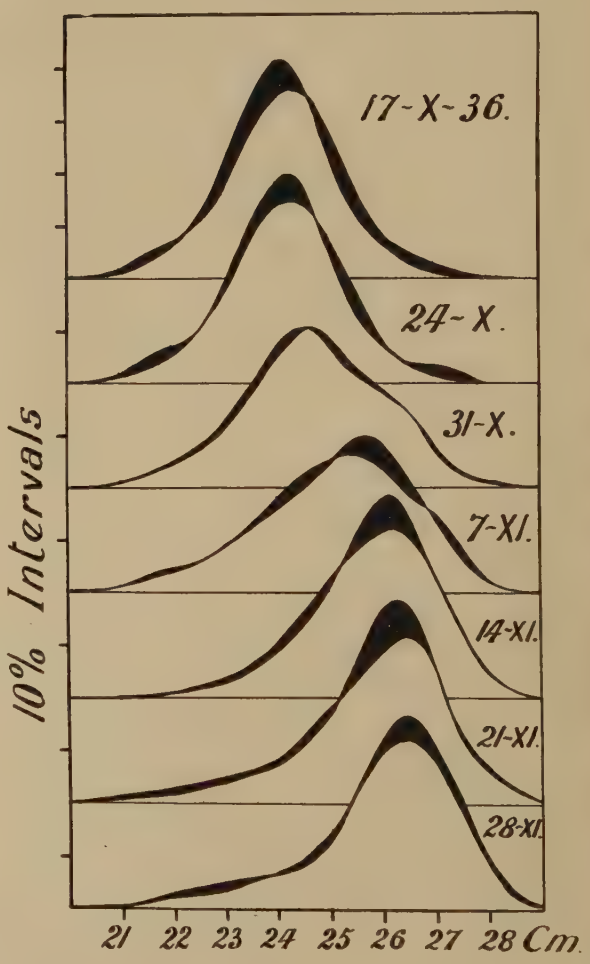


Fig. I. Length, 1936.

Table IV.

Sample from Yarmouth **9—10 - 37**

Length cm.	Age Analysis									Measurer's Totals	
	3	4	5	6	7	8	9	10	10+	No.	%
19	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—	—
21	10	—	—	—	—	—	—	—	—	10	0·3
22	74	9	—		—	—	—	—	—	83	2·8
23	150	106	—	—	—	—	—	—	—	256	8·6
24	174	373	95	8	—	—	—	—	—	650	21·9
25	37	329	409	102	7	7	—	—	—	891	30·1
26	—	68	271	158	98	23	7	—	—	625	21·1
27	—	14	35	69	49	63	49	28	7	314	10·6
28	7	7	—	20	13	20	33	13	—	113	3·8
29	—	—	—	—	—	6	7	8	—	21	0·7
30	—	—	—	—	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—	—	—	—	—
(*a*) Calculated Totals	452	906	810	357	167	119	96	49	7	2963	—
(*b*) Factor oz.	3·98	4·75	5·43	5·61	5·93	6·16	6·37	6·37	6·37	—	—
(*c*) Equiv. Wt. oz.	1798·96	4303·50	4398·30	2002·77	990·31	733·04	611·52	312·13	44·59	15195·12	—

(*d*) Total weekly landings = 19,297 (crans) × 3.75 = 72,363·75 cwt.

(*e*) Weekly Landings cwt.	8567·19	20494·57	20946·03	9537·80	4716·16	3490·96	2912·74	1486·46	212·35	—	—
(*f*) Do. oz. 000' omitted	15352	36726	37535	17092	8451	6256	5219	2664	381	129676	—
(*g*) Factor	3·98	4·75	5·43	5·61	5·93	6·16	6·37	6·37	6·37	—	—
(*h*) Total Estimated No.s 000's omitted.	3857	7732	6913	3047	1425	1076	819	418	60	25287	—

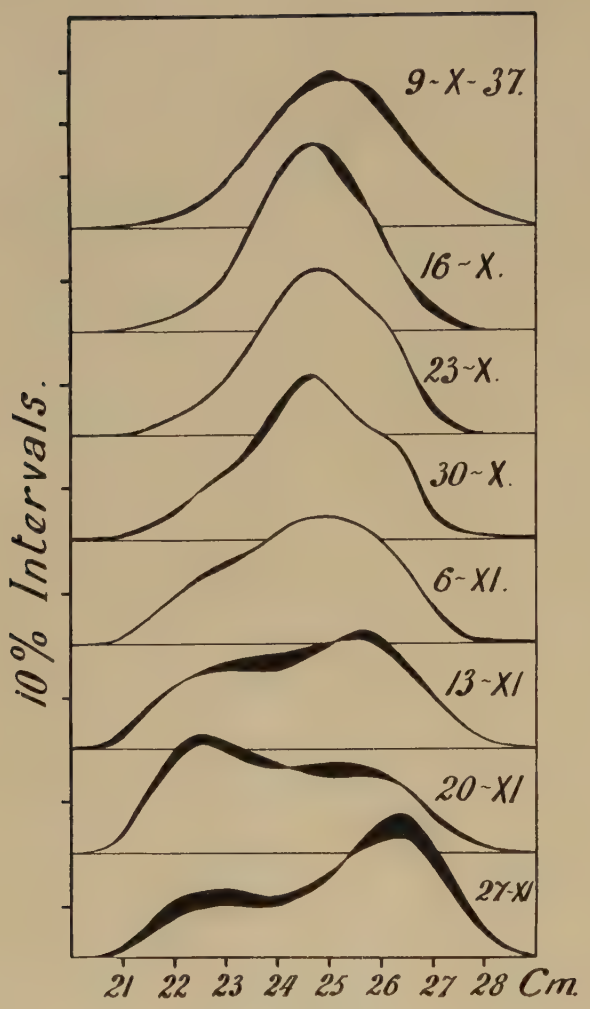


Fig. II. Length, 1937.

Length.

Figures I and II show the results of the market measurements of herrings during the seasons 1936 and 1937. The frequency curves are drawn according to the method described by Wollaston and Hodgson[1]). The curves representing the measurements at Yarmouth and Lowestoft have been superimposed so that the degree of divergence can be easily seen at a glance. The length-frequencies have been reduced to percentages, and the curves therefore show equal areas on the drawings. This fact makes it a simple matter to separate the individual curves if necessary.

In the 1936 measurements it is clear that, with the possible exception of the curves for the week ending 7th November, there are no great variations in the figures. The chief characteristics of the shoals as shown by the modes are visible in both sets of records, and the slight difference in the curves for the week ending 7th November is no doubt due to the fact that at this time the small herrings were leaving the ground and their place was being taken by the bigger fish.

The 1937 figures show the accuracy of the measurements by the two assistants, for in many cases there is practically no overlap at all. The peculiar curve for the week ending 6th November is equally well produced at both ports, and the late advent of the young fish is also clearly shown.

The experience of many years of measurements at our two herring ports has shown that the masses of fish caught by the fleets operating from those ports are virtually identical.

Age.

Figures III and IV show the estimated numbers of herrings of each age per landings during each week of the seasons 1936 and 1937 at Lowestoft.

In 1936, the four-year-old herrings formed the main bulk of the "recruit spawners", and these fish came into the shoals in increasing numbers until October 31st, after which date they gradually disappeared. The old spawners — the main age-groups being those of seven and nine years — reached their maximum at a later date.

In 1937 the five-year-old fish reached their maximum about October 30th, and at this time the older fish were just entering the shoals. This was quite normal but 1937 was noteworthy for the peculiar behaviour of the three-year-old herrings. These fish, instead of arriving early as is usual, did not appear in appreciable quantities until October 30th and by November 20th they formed the bulk of the catches.

The data which formed the basis of the above Figures III and IV were obtained from column (h) on the form illustrated in Table IV, which shows the estimated numbers of fish at each age in the total weekly catch. Now, the number of landings made every week by the fleet at each port is known to the statistical officers on the markets, so by dividing the totals in column (h) by the number of landings during the same period the average number of herrings of each age per landing is found. This is found to be a convenient unit with which to work, and the actual importance and variation of the several age-groups is more easily seen in this way than by considering total weekly landings only. In recent years the drift fishery of East Anglia has been controlled in order to attempt to regulate supplies on the market, and in many cases the number of individuals in the age-groups in the weekly tables has been governed by the activities of the fleet. Actually what is wanted is an index of the intensity of fishing from week to

[1]) A new method of treating frequency curves in fishery statistics, with some results — *Journ. du Cons. Int.*, Vol. IV, No. 2. 1929. (Copenhagen).

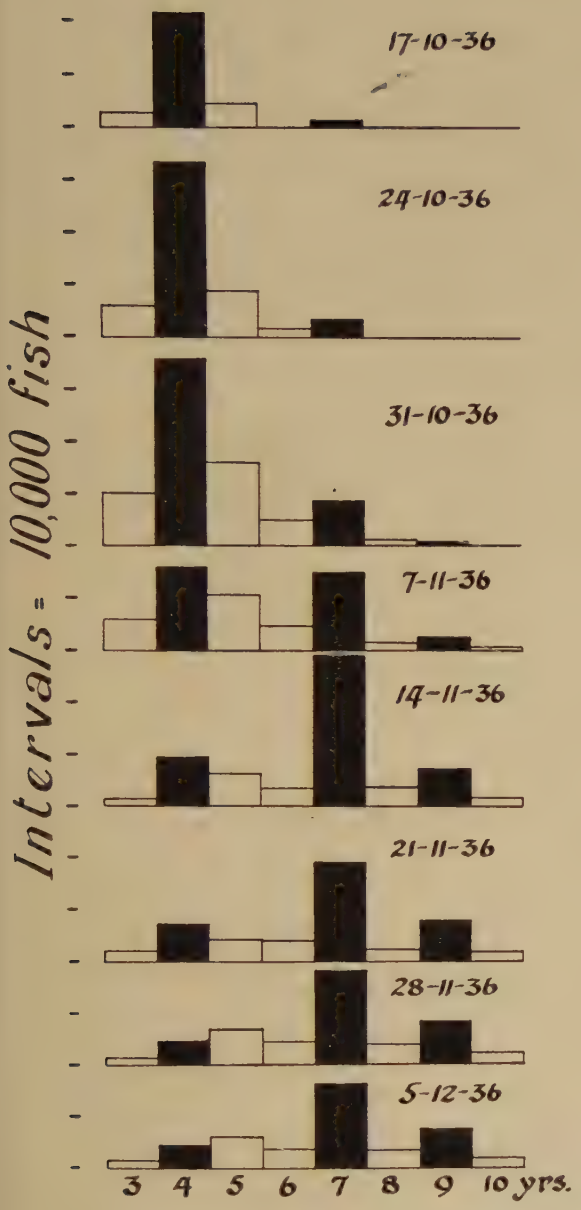


Fig. III. Average Landing per Week, 1936.

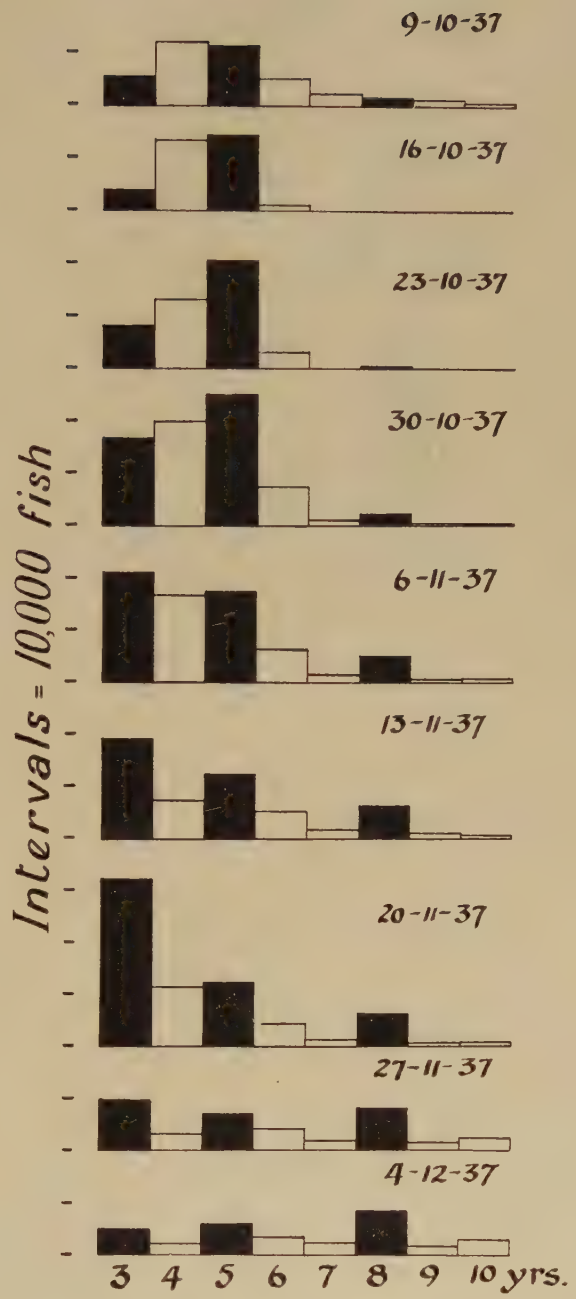


Fig. IV. Average Landing per Week, 1937.

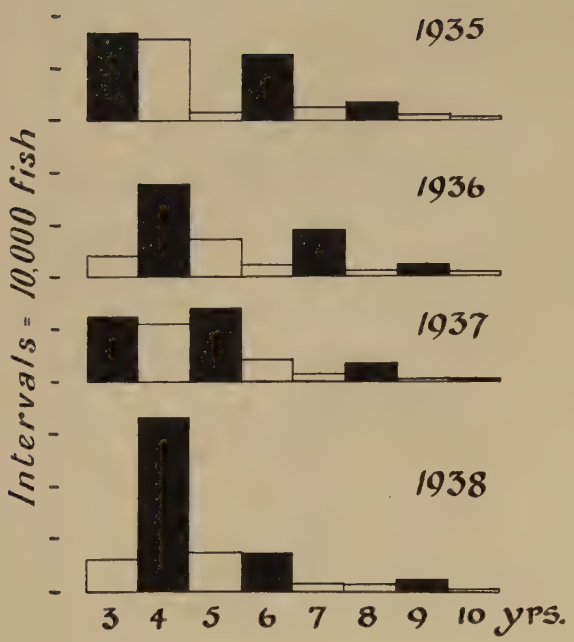


Fig. V. Average Landing, 1935—38.

week, and the *catch per landing* is the most convenient way of expressing this.

Lastly, Figure V shows the age-composition of the average landing during the four fisheries of 1935—38. These are obtained in the same way as before, by dividing the estimated number of fish in each age-group during a complete season by the total number of landings made at Yarmouth and Lowestoft. The age-distribution for any year is now directly comparable with that of the other years and the *actual* decrease in the strength of a year-class can now be studied, since the figures represent numbers of herrings and not percentages.

The change in the numerical value of the major year-classes (shown in black) as they increase in age is so clearly seen as to need no comment, and it is obvious that soon it will be possible to make mortality calculations of greater accuracy than those made hitherto by the use of percentages.

5.

THE EFFECT OF FISHING ON THE STOCK OF PLAICE IN THE NORTH SEA.

BY

D. E. THURSBY-PELHAM

Introduction.

COMPLAINTS of the over-fishing of the Plaice stock of the North Sea are of very long standing. It was inevitable that with the spread of trawling over the whole area between 1860 and 1882, the accumulated stock of large fish would decline and that an equilibrium would be reached when, though the actual weight of the landings was as great, the average size of the fish was smaller. Unfortunately any statistics of the landings of plaice from the North Sea are unobtainable before 1892 and cannot be said to be reliable for the total landings by all countries before 1906 at the earliest. However, the outcry on the destruction of "immature fish" and the demand for their protection was the main cause of the formation of the "National Sea Fisheries Protection Association" in 1882, by the trawler owners themselves. As a result of their agitations an International Conference was held in London in 1890 to consider the possibility of protecting young fish. Although their deliberations were fruitless in so far as no practical remedies were adopted, the seeds were sown from which systematic scientific investigations of fishery problems began to grow.

The first of these that is of value for the purpose of comparing the average size of North Sea plaice at that time, with that of the present day, was the work carried out by Mr. Holt (7), of the Plymouth Marine Biological Association, at Grimsby between 1892 and 1894. His results (8) can be compared with the data obtained by the Ministry since 1931.

When Mr. Holt collected his statistics, the method of fishing at Grimsby was very different from what it is now. Instead of by a fleet of steam trawlers using the highly efficient Vigneron-Dahl Otter trawl, it was carried on in the main by sailing trawlers in the ratio of about 4 sailing vessels to one steam trawler. Both steam and sail still used the old Beam trawl as the Granton Otter trawl for steam vessels was not adopted till 1894.

The sorting of plaice on the market was also very different as they were divided only into two categories "Large" and "Small" which varied in themselves according to the amount of very small fish landed, instead of the present very definite eight categories. Moreover plaice as small as eight inches were marketed instead of nine inches as enforced by present regulations. Yet, a comparison between Holt's data (8) and that obtained by the Ministry shows that the *average* size of the fish landed must have been considerably larger. This can be deduced by a comparison of the number of fish per cwt:—

Table I.

Number of fish per cwt. at Grimsby.

	March	June	Sept.	December
Holt, average 1893 and 1894	101	142	97	91 (1893 only)
M. A. F. average 1931—37	183	207	182	139

There must therefore, have been a proportionately greater number of larger plaice in the sea during the earlier period than there is now. Further comparisons can be made, as Holt estimated the number of fish above and below 13 inches (33 cm.) and also 17 inches (43 cm.) respectively, in the landings each month. These are compared with the landings in 1937, in Table 2 and illustrated graphically in Fig. I.:—

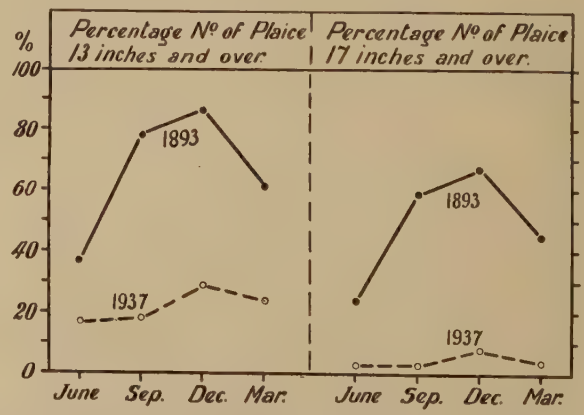


Fig. 1. The percentage number of Plaice of 13 inches and over and of 17 inches and over, landed at Grimsby from the North Sea in certain months in 1893 and 1937.

Table 2.

	No. 13 inches and over	%	No. below 13 inches	%	No. 17 inches and over	%	No. below 17 inches	%	Total cwt. landed
June									
1893	752,325	37	1,266,925	63	481,600	24	1,537,650	76	13,731
1937	720,690	17	3,426,270	83	133,643	3	4,013,317	97	20,042
Sept.									
1893	1,032,400	78	291,600	22	787,500	59	536,500	41	13,552
1937	725,844	18	3,237,426	82	113,191	3	3,850,079	97	20,995
Dec.									
1893	405,645	86	64,405	14	313,810	67	156,240	33	5,141
1937	791,323	29	1,907,322	71	203,922	8	2,494,723	92	19,496
March									
1894	651,635	61	409,515	39	477,330	45	583,820	55	9,378
1937	803,647	24	2,535,166	76	126,951	4	3,211,862	96	18,500
Totals for the 4 months									
1893—94	2,842,005	58	2,032,445	42	2,060,240	42	2,814,210	58	41,802
1937	3,041,504	21	11,106,184	79	577,707	4	13,569,981	96	79,033

Although nearly three times as many fish were landed in these months in 1937 than there were in 1893—94, the number of plaice of over 13 inches was almost the same, while there were less than one third of the plaice of over 17 inches landed in 1937.

It may be argued that although the average size of the fish was higher in 1893—94, the total yields from the North Sea as a whole, was smaller. We have no very reliable statistics to show whether or not this was the case, but Kyle (9) gives figures of the landings from the North Sea by the principal countries, which indicate that much the same weight was landed then as in recent years. Kyle considered that the figures he gives in his Table VII (9 p. 29) show an over-estimate of 5 million kilogrammes. If we make this deduction, the landings for 1893 and 1894 were approximately 48 million kilogrammes in both years, figures which do not differ widely from the 47 million kilogrammes landed both in 1935 and 1936 — as published in the Bulletin Statistique (2). If Kyle's figures are correct, the North Sea is capable of producing as great an actual yield in weight but of fish of the much larger average size, as shown by Holt's figures, than it does at the present time.

The North Sea, moreover, in 1893 could not be regarded as a virgin ground that had an accumulation of large fish due to lack of fishing, since the English trawlers had been working the plaice grounds for the previous 20 years and the old stock must by then have been removed. Evidence for this is given by Mr. Alward's figures (see 5 p. 65) of the landings of certain Grimsby sailing trawlers from 1875 to 1892. These are referred to in more detail later but they show that the average annual catch of plaice per vessel in 1892 was only a quarter of what was obtained in 1875.

Before discussing the progressive decline in size and abundance, it is necessary to see how the methods of fishing have altered between the time of Holt's researches and the present day.

A. Developments in Methods of Trawling.

It was fortunate that Holt's investigations were made in the period which marked the end of one era in fishing methods. In 1893—94 trawling was still carried on mainly by fleets of sailing vessels together with a few steam trawlers, both classes of vessels using the Beam trawl. In 1894 the Granton Otter trawl began to be adopted and steam gradually superseded sail to so great an extent that by 1906, 77 per cent of the plaice in the North Sea were landed by 1st Class steam trawlers, which up to the war usually worked trawls without bobbins or ticklers.

How much more effective was the Otter trawl of that time than the Beam trawl, when used by the same type of vessel as an instrument for catching plaice is uncertain, since no data are available of comparative catches per unit of time. According to Garstang (5) the trawler men believed that it increased the catching power of fish as a whole up to 50 %. There can be no doubt, however, that the Steam Otter trawler caught more than twice as much plaice as the Sailing Beam trawler. Garstang showed this in his Table IX (5 p. 45). This can also be seen at a glance from the detailed statistics of the catch per day's absence from port published in the Annual Reports of the Board of Agriculture and Fisheries (2) from 1906—1913.

Kyle (9 p. 28) writing in 1904 states that

about 17 per cent of the North Sea plaice area was untrawlable owing to rough or rocky ground, but after the war, according to Graham (6 p. 63), bobbins gradually came into general use and grounds that were previously regarded as unfishable were regularly fished. If Kyle was correct this meant that certain areas which must have afforded some degree of protection to the stock before the war, ceased to provide sanctuaries soon after it.

The next important development in trawling methods was the invention of the Vigneron Dahl gear and its many adaptations. This began to be adopted in 1923 and came into general use in the next five years. To what extent it increased the catching power of the trawl with regard to plaice, cannot be estimated with very close accuracy. Bowman (1 p. 15) stated that it caught 50 per cent more haddock, but our own comparisons of measurers' results on board different vessels working in the same rectangles using the ordinary trawl and the Vigneron Dahl gear do not show so great an increase in catching power. A conservative estimate of the increase can be put at 25 per cent. That it did have a considerable effect can be shown by comparing the landings per 100 hours' fishing of steam and sailing trawlers in the Southern North Sea (4) — the operations of sailing trawlers being confined to this area. The figures are as follows:—

3. The increased use of bobbins and ticklers after the war, thus increasing the trawlable areas.
4. The adoption of the Vigneron Dahl trawl gear and its adaptations between 1924 and 1929.
5. The increase in size of vessels.

B. The Landings and Abundance of Plaice 1906—1937.

1. Landings.

The total landings of plaice by all countries fishing the North Sea, and by those countries which together landed over 80 per cent of the total are given in Table 4 and illustrated graphically in Figure 2 from 1906—1936 — the latter being the last year published in the Bulletin Statistique at the time of writing. (2)

As far as the actual quantity landed is considered there does not appear to be any great indication of over-fishing. It was still, in 1936 nearly up to the pre-war average. Yet, despite the many improvements in gear, the English landings have declined steadily. In fact, the English vessels found that the North Sea was becoming less and less profitable and most of the country's fishing effort was diverted to other grounds. This decline in North Sea fishing, both of steam and sailing

Table 3.

Landings (cwt.) per 100 hours fishing of steam and sailing trawlers in the Southern North Sea. (IVC)

Year	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Steam Trawler ..	24	27	32	33	30	33	29	28	27	31	30	31	32	31
Sailing Trawler .	11·6	12·9	12·6	12·8	10·9	11·0	9·5	8·5	7·8	7·7	7·5	7·3	9·6	9·4

It is obvious that while the landings of sailing trawlers have remained persistently below the level of 1925, those of the steam trawlers have been well above it with the exception of 1932.

Another factor, unfortunately intangible owing to the lack of detailed statistics, is the increase in the size of steam trawlers. The average tonnage per vessel of the total steam trawlers fishing from English ports has risen from 201 tons in 1913 to 271 tons in 1936, but since this includes the very large vessels fishing the distant fishing grounds, it is not possible to say how greatly the size of vessels fishing the plaice grounds of the North Sea have increased, though it is probable that their average tonnage is greater than pre-war.

To sum up, the principal changes which have affected the English methods of trawling and therefore the intensity of fishing are as follows:—

1. The adoption in 1894 of the Granton Otter trawl.
2. The gradual reduction of sailing vessels and increase of steam trawlers, until by 1936 only 60 sailing trawlers were fishing the North Sea.

trawlers, began in 1908 and fell almost continuously until the war when, owing to hostilities, the drop was precipitated. In 1920 there was a great increase in the English landings — indeed it returned to the level of 1907, only to fall again almost regularly until the present day. Between 1924 and 1937 the decrease in the number of hours fishing by steam trawlers in the North Sea amounted to 26 per cent. while that of sailing trawlers was 88 per cent.

It must, however, be stated emphatically that although the number of hours actually spent in fishing by English vessels was less, the intensity of fishing of the stock by all nations has *not* declined, owing to the increased efficiency of the gear employed by the English, and the increased intensity of fishing by certain other nations. While English fishing declined, the fishing for, and the landings of plaice by the Danes has risen enormously, and reached their peak in 1929 and 1930. The landings in the Netherlands also rose during the years 1926 to 1929. German landings have been more stable in recent years, except from 1917 to 1920 when they were doubled. Since 1929 there

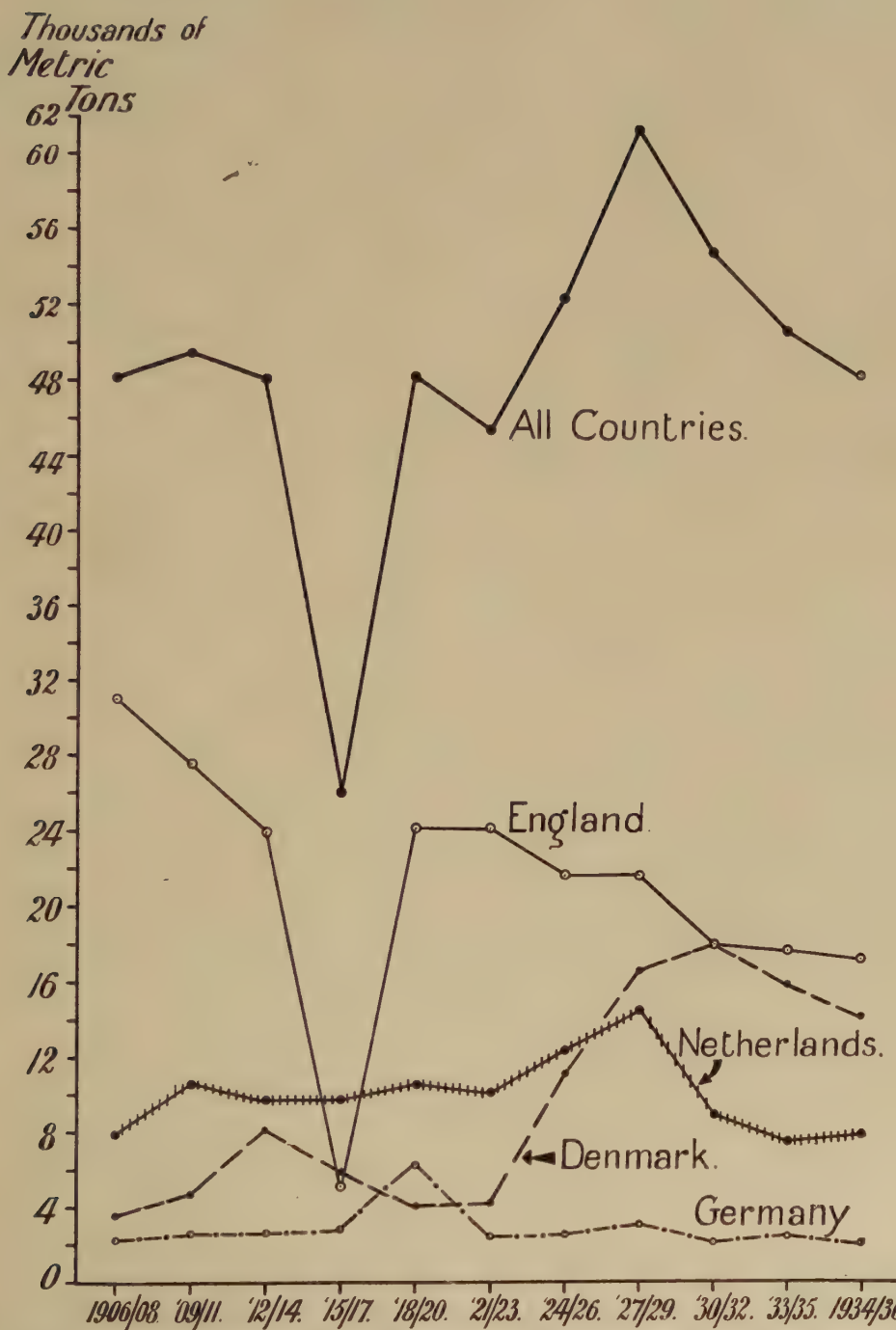


Fig. 2. Total landings of Plaice by all countries from the North Sea, together with the shares landed by English, Danish, German and Dutch vessels, 1906 to 1936. Smoothed by threes.

Table 4.

Total Quantity of Plaice landed from the North Sea in metric tons (000's omitted) and the Landings from the Principal Countries, with Percentages of the total landed by each country.

Year	Total	Germany		Denmark		Netherlands		England	
		Total	%	Total	%	Total	%	Total	%
1906	45	2	4·7	3	7·0	8	16·7	29	64·3
1907	52	2	4·3	5	8·9	9	16·9	33	63·6
1908	47	3	5·5	3	6·4	8	16·1	31	65·4
1909	49	3	5·6	4	7·8	9	18·1	30	61·4
1910	48	3	5·7	5	10·8	10	21·6	26	53·6
1911	52	2	4·6	5	10·3	12	23·8	27	52·9
1912	52	2	4·7	9	17·4	10	19·0	27	51·5
1913	50	3	6·1	9	18·4	10	20·0	25	49·4
1914	43	2	5·8	6	14·2	9	22·2	21	48·2
1915	28	1[1])	4·8	10	35·2	8	28·1	6	23·2
1916	25	3[1])	10·6	6	22·8	10	37·5	5	19·1
1917	25	4[1])	17·4	2	8·7	12	48·0	4	15·9
1918	40	8[1])	20·9	3	7·2	12	31·0	15	36·0
1919	50	6	11·6	5	10·5	11	22·7	25	49·0
1920	55	4	8·0	4	7·1	8	14·0	33	61·3
1921	44	3	7·2	3	6·7	9	20·9	24	54·1
1922	50	3	5·1	5	9·2	12	23·9	26	51·9
1923	43	2	3·6	5	12·0	9	21·6	23	53·4
1924	46	2	4·7	6	12·9	11	23·8	22	49·2
1925[2])	56	2	4·4	13	23·3	12	21·9	23	41·8
1926	56	3	5·3	14	25·6	14	24·7	20	34·7
1927	55	3	5·7	11	19·8	14	25·2	22	40·4
1928	64	3	4·9	18	27·7	17	26·2	22	34·0
1929	66	3	4·5	21	32·3	13	19·8	21	32·0
1930	62	3	4·1	20	32·9	11	18·6	20	31·9
1931	52	2	4·1	16	30·2	8	15·6	18	34·8
1932	51	2	3·5	18	35·4	7	14·3	16	32·2
1933	54	3	5·8	18	33·1	7	13·9	18	33·5
1934	52	2	4·3	16	31·6	7	13·9	19	36·0
1935	47	2	4·3	14	28·9	8	16·8	17	35·2
1936	47	2	4·0	13	26·9	9	18·3	17	35·6

[1]) German figures admitted to be underestimated.
[2]) France not included previous to 1925.

has been almost a continuous decline in the landings by all nations combined, and in 1936, with the exception of those of Denmark, the landings of each country separately had fallen to below the pre-war level.

So much for the actual landings. These, however, do not necessarily mean that the stock has diminished. A fall in landings may be due to a slackened demand of the particular fish in question, or markets may be difficult to obtain, as in the case of the herring. No such argument, however, can be brought forward in the case of plaice, as it is always in demand. Any falling off in supplies must be due either to an actual shortage or because the bulk of the fish captured are too small to make catching them a profitable undertaking.

2. Abundance.

The abundance of plaice can be estimated to some extent by the landings per unit of time of a definite class of vessel.

Garstang (5 p. 24) gives an excellent summary of the available data for the years when trawling by English sailing vessels had spread over the North Sea plaice grounds. The figures are based on the landings of 4 vessels belonging to Mr. Alward (see Table 5).

The unit of time used is the long one of a year but the interpretation is clear — that there was a tremendous decline in the abundance of plaice during the period under review. It must be remembered, however, that trawling had only partially spread over the North Sea in 1867 and that the off-shore grounds were still in a nearly virgin condition with an accumulated stock of fish. With the introduction in 1875 of the Steam carriers which conveyed the catch quickly from the sailing trawler fleets to the markets, the area of fishing spread rapidly and the number of vessels was increasing steadily. The accumulated stock was fished up and the fishery became more dependant on the normal recruitment.

Table 5.

The Average Annual catch of four Grimsby Trawling smacks in 1867 and from 1875 to 1892.

	Plaice	Haddock	Prime[1])	Rough[2])	Total
1867	998	831	137	46	2,012
1875	549	937	63	30	1,565
1876	601	891	50	33	1,576
1877	421	668	88	21	1,198
1878	254	481	76	31	843
1879	298	488	98	44	928
1880	291	359	65	39	754
1881	242	280	84	70	675
1882	385	717	84	86	1,273
1883	340	665	97	74	1,177
1884	325	526	96	79	1,025
1885	280	477	90	89	936
1886	250	510	77	87	925
1887	221	475	62	87	846
1888	195	372	42	57	667
1889	177	342	64	69	652
1890	205	465	47	65	783
1891	203	590	47	79	920
1892	168	436	29	49	683

[1]) "Prime" includes soles (excluding lemon soles), turbot and brill.

[2]) "Rough" includes lemon soles, dabs, cod, catfish, rokers, (rays) and other kinds.

When statistics were placed on a reliable basis in 1906, the catch per unit of time of English steam and sailing trawlers was calculated. Up to 1922 the unit used was the "landings per day's absence from port", but from that date the more accurate method of the "landings per 100 hours' fishing" was employed as well. Since, as already mentioned, the Vigneron Dahl trawl gear and the use of ticklers and bobbins increased the catching power of steam trawlers from 1926 onwards, it would not be correct to compare the landings per day's absence of steam trawlers before and after that date. Table 6 shows

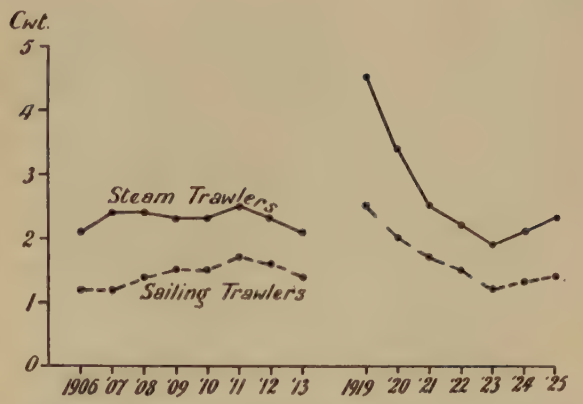


Fig. 3. Cwt. of Plaice landed in England per day's absence from port by 1st class British Steam and Sailing Trawlers from the North Sea.

it is of interest at this point to remark that the plaice landed from 1919 to 1921 were nearly all 'Large' and 'Medium' fish with a very small proportion of 'Small', and were caught on the off-shore grounds which indeed, at the time, were teeming with large fish of all kinds. A glance at Table 4 shows that the total landings from the North Sea from 1919—1921 were not greatly above the pre-war level. How was it, then, that the fall in abundance was so catastrophically rapid? The reasons have been fully given in my report (10) and are here recapitulated briefly.

During the war fishing on the off-shore grounds was negligible owing to the danger of mines and submarines, but at the same time there was an enormous increase of fishing on the continental inshore grounds, which are the nurseries for plaice, by the Germans and the Dutch. In this way the oncoming stock was so reduced that by the time the bulk of the stock which had accumulated during the war had been caught, there was both during, and shortly after the war, a great shortage of

Table 6.

Landings (cwt.) of Plaice by 1st Class English Steam and Sailing Trawlers, per day's absence from port, from the North Sea.

	1906	1907	1908	1909	1910	1911	1912	1913	1919	1920	1921	1922	1923	1924	1925
Steam Trawlers ...	2·1	2·4	2·4	2·3	2·3	2·5	2·3	2·1	4·5	3·4	2·5	2·2	1·9	2·1	2·3
Sailing Trawlers ..	1·2	1·2	1·4	1·5	1·5	1·7	1·6	1·4	2·5	2·0	1·7	1·5	1·2	1·3	1·4

the changes which took place between 1906 and 1925, with the war period omitted:— (5 and 6).

These figures which have been plotted in Figure 3 show the same features in both types of vessel, — that of a state of virtual equilibrium before the war and a striking increase immediately after it, followed by a very sharp decline. The question of the average size will be discussed fully later but recruits to keep the stock replenished. It was not indeed till 1924—25 that the main plaice grounds were restocked by the abundant year-classes spawned between 1919 and 1922, when the stock of mature plaice was large.

From 1922 onwards the abundance can be shown to some extent by the landings per 100 hours' fishing published in the Ministry's official

Table 7.

Landings (cwt.) of Plaice per 100 hours' Fishing by 1st Class British Steam Trawlers and Sailing Trawlers from the North Sea and from each Sub-region of the North Sea. Figures published in the Ministry of Agriculture and Fisheries Statistical Tables and figures adjusted to the Vigneron Dahl trawl gear from 1926 onwards.

		1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Steam Trawlers.																	
North Sea. IV	Official Figures	14	12	14	15	16	16	16	17	16	17	16	17	17	19	19	
	Adjusted to V.D.	14	12	14	15	14	14	13	14	13	14	13	14	14	15	15	
Sub-region IVA	Official Figures	Not available			1	1	1	1	1	1	1	1	0	0	1	1	
Adjustments to V.D. not calculated																	
IVB	Official Figures				13	14	14	15	16	15	15	15	15	15	17	17	
	Adjusted to V.D.				13	14	12	13	13	12	12	12	12	12	14	14	
IVC	Official Figures				24	27	32	33	30	33	28	27	31	30	31	32	31
	Adjusted to V.D.				24	27	28	29	24	26	23	22	25	24	25	26	25
Sailing Trawlers.																	
North Sea (IVC)	Official Figures	15·0	11·0	11·6	12·9	12·6	12·8	10·9	11·0	9·5	8·5	7·8	7·7	7·5	7·3	9·6	9·4

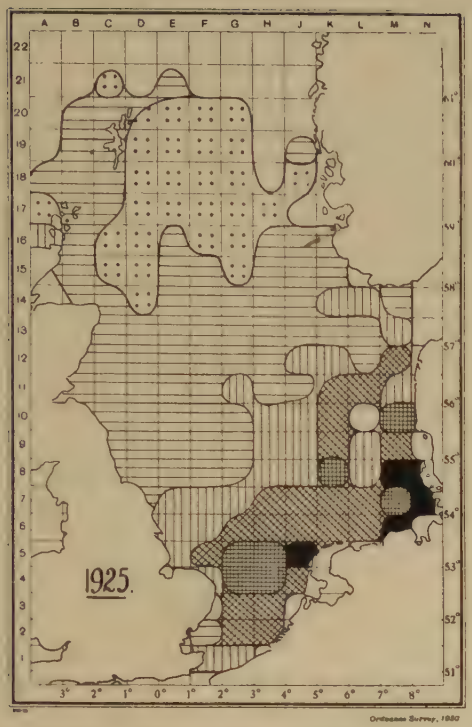
been adopted universally, and reduced by ¼ from 1928 onwards when the ordinary Granton trawl had passed into disuse to a very great extent.

While these adjusted figures give a more truthful idea of the present comparative abundance of plaice, they do not tell the whole story. From Table 7 it would appear that in 1936 and 1937 plaice were actually as abundant, taking the North Sea as a whole, as they have been at any time during the last 16 years and that the abundance in the middle North Sea (IVB) is as great now as it was in 1925, the southern North Sea (IVC) alone showing a decline. To any one who has followed the plaice fishery during the period 1922—1937, the idea of any increase of abundance is an absurd fallacy. The fallacy arises from the fact that rises and falls in the quantity landed per 100 hours' fishing over these large areas depends not only on the stock of plaice present but on whether the vessels have been fishing more or less on the grounds where plaice are plentiful.

In the statistics the total landing of plaice is divided by the number of hours spent in fishing for all species over the whole North Sea or in each of its three main sub-divisions. This is unavoidable, but it does mean that if, for example, haddock are scarce, more time is spent in fishing for cod and plaice on the grounds where the cod or plaice are most abundant, and the landings of these species for 100 hours' fishing thus rises artificially. The comparative abundance of plaice from one year to another can, therefore, only be accurately determined by comparing the charts giving the landings per 100 hours' fishing in each rectangle where the plaice are caught. The English Department furnishes charts, both monthly and yearly, of the total landings and the landings per 100 hours' fishing of English and Scottish steam trawlers in each rectangle of the North Sea. These figures have been summarised for the year 1925 which is based on the original data and for the period 1929 to 1937 where the landings per 100 hours' fishing in each rectangle have been reduced by ¼ to allow for the increased efficiency of the gear; they are shown diagrammatically in charts Fig. 4 A—K. The most salient features of these charts are (a) the gradual increase of the area yielding less than 1 cwt. per 100 hours' fishing until 1935, after which the outline remained fairly stationary; (b) the virtual disappearance after 1931 of the areas yielding over 40 cwt., and (c) the shrinkage of those yielding more than 30 cwt. from 1932 onward. The decline in abundance both of the 20—29 cwt. and 30—35 cwt. areas in recent years on the most easterly grounds is very marked.

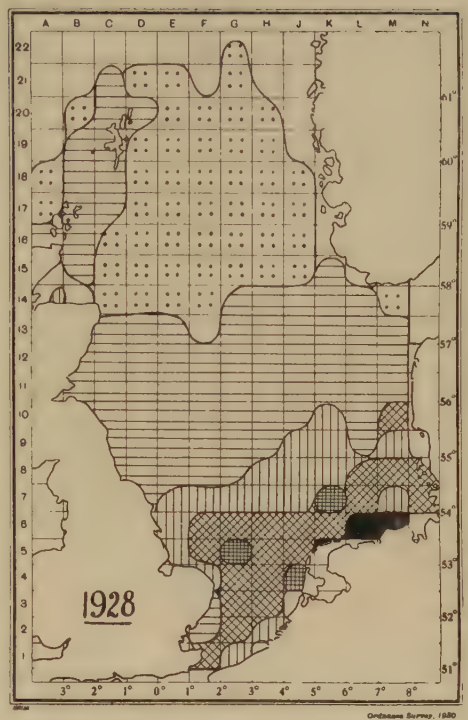
Since, however, it is difficult to follow these changes in detail over so many years, the main alterations can be more clearly shown by comparing 1925 and alternate years from 1929 to 1937, (Fig. 5 A—F). These give a very striking picture of the decline in abundance since 1925 and can leave no

statistical tables. These tables, however, do not allow for the increased efficiency of the Vigneron Dahl gear and the use of bobbins and tickler. In order to obtain a truer comparison, the actual figures have been reduced by $^1/_8$ in 1926 and 1927, when, although the gear was widely used, it had not



+ A.

As to signatures, see Fig. 4K.



+ B.

Fig. 4, A—B. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1925 and 1928.

+ C.

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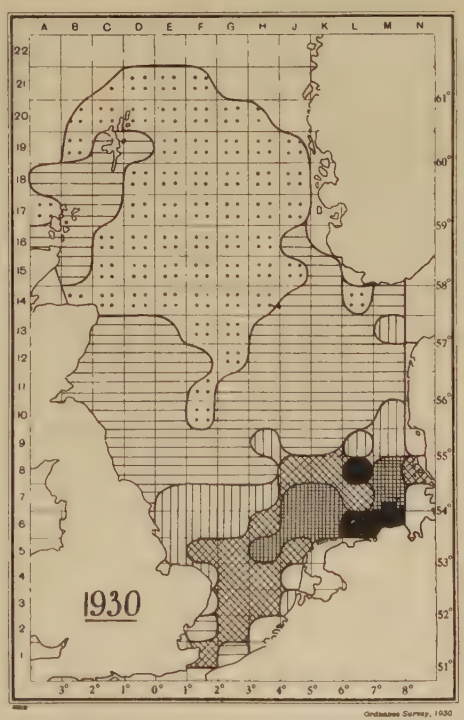
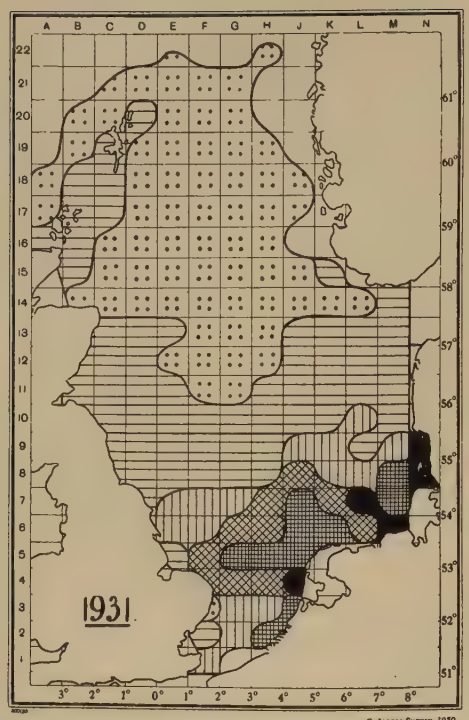


+ D.

Fig. 4, C—D. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1929 and 1930.



4 E.

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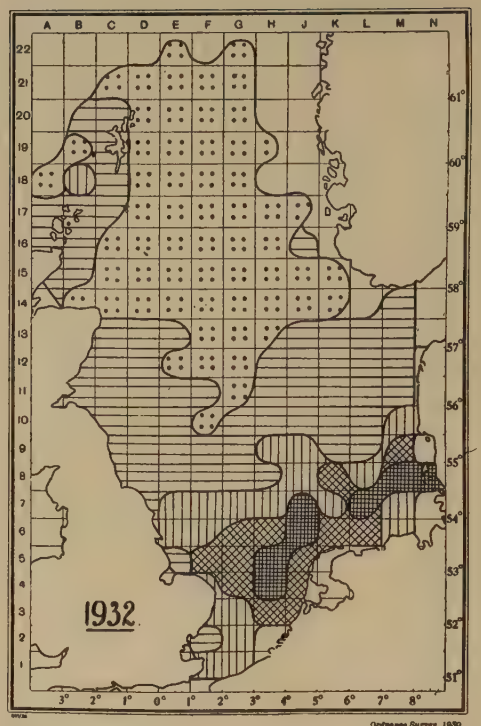
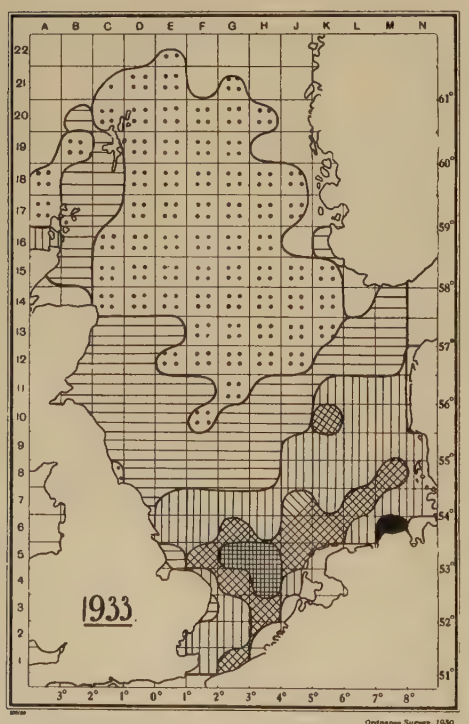


4 F.

Fig. 4, E—F. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1931 and 1932.



4 G.

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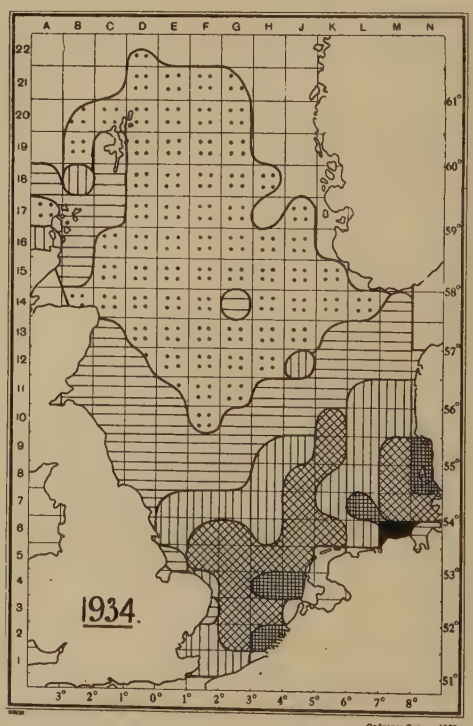
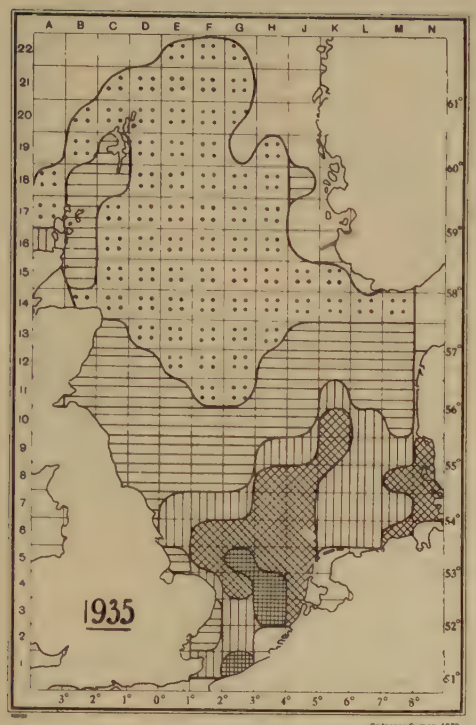
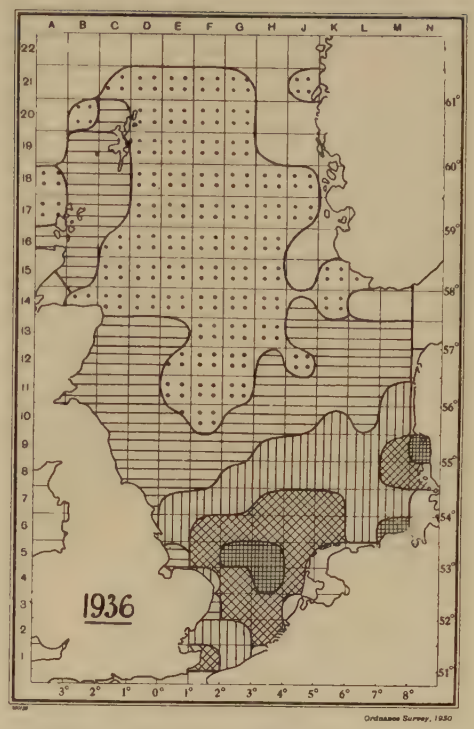


4 H.

Fig. 4, G—H. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1933 and 1934.

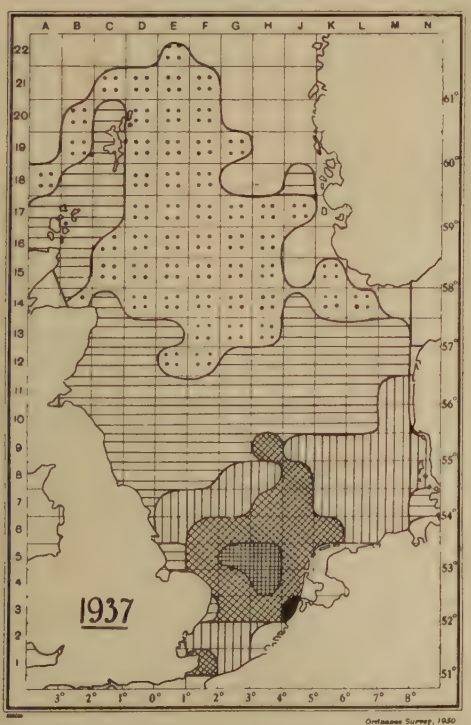


4 I.



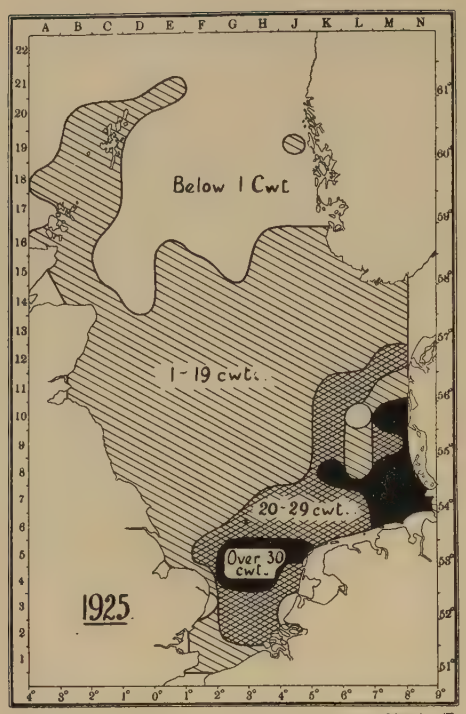
4 J.

Fig. 4, I—J. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1935 and 1936.



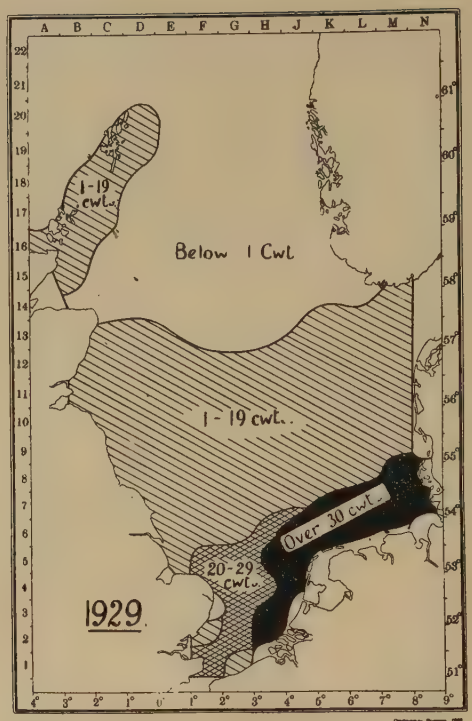
4 K.

Fig. 4, K. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1937.



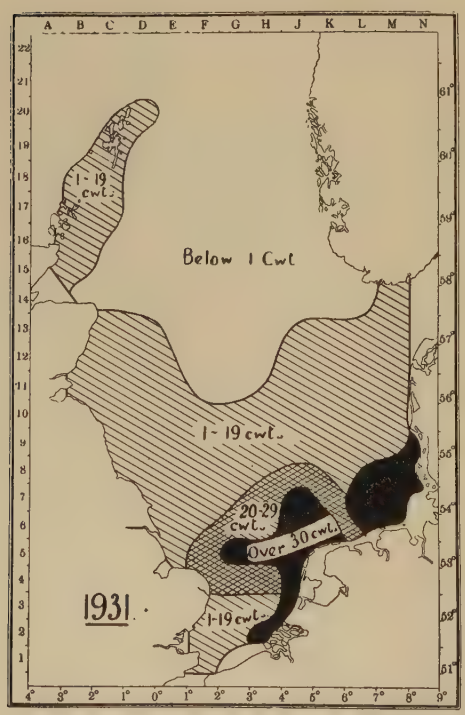
5 A.

As to signatures, see Fig. 4K.



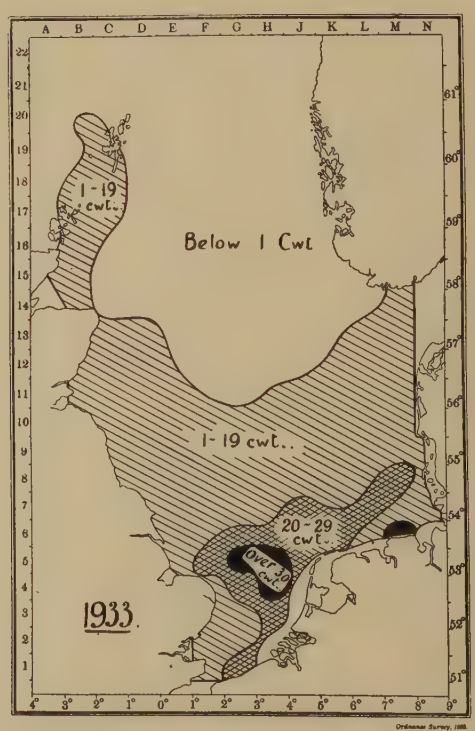
5 B.

Fig. 5, A—B. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1925 and 1929.



5 C.

As to signatures, see Fig. 4K.



5 D.

Fig. 5, C—D. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1931 and 1933.

5 E.

5 F.

Fig. 5, E—F. Landings per 100 hours' fishing (cwt.) of Plaice by British Steam Trawlers in 1935 and 1937.

doubt of the lamentable decrease which has taken place.

There is, however, another aspect besides the effects of fishing to be taken into consideration. This is the effect of major fluctuations in the survival of the brood each year. This undoubtedly has a considerable influence on the landings but is masked in these statistics and charts dealing with the North Sea as a whole, since vessels fish where they hope to get the best catch possible and leave the grounds where they have found plaice either to be scarce or even where they are abundant, if the average size is too small for fishing to be profitable.

The effects of fluctuations are best seen in the more detailed statistics of individual ports and are dealt with in section E.

C. Changes in the Average Size Distribution of the Stock.

The lowering of the average size that occurred between 1893 and 1937 has already been dealt with in the introduction as far as the data for the earlier period permits. After 1906 particulars were collected of the three main statistical categories, Large, Medium and Small. The total landings are given in Table 8.

The yearly percentage of large, medium and small plaice have been graphically shown in figure 4.

It must be emphasized that the sorting of plaice altered so radically after the war that the pre- and

Table 8.

Total Quantity of Plaice (Tons) landed from the North Sea by all British Vessels at English Ports 1906—37.

	Large	%	Medium	%	Small	%	Unsorted	%	Total
1906	10,303	36·0	7,144	25·0	9,027	31·6	2,142	7·5	28,616
1907	8,193	25·2	7,872	24·2	14,337	44·0	2,149	6·6	32,551
1908	7,630	25·0	7,740	25·3	12,683	41·5	2,487	8·1	30,540
1909	6,429	21·7	8,530	28·8	13,666	46·1	991	3·4	29,616
1910	5,487	21·6	8,276	32·6	10,589	41·7	1,035	4·1	25,387
1911	5,143	19·2	8,068	30·0	12,893	48·0	746	2·8	26,851
1912	5,042	19·0	8,636	32·6	10,999	41·5	1,817	6·9	26,494
1913	4,932	20·3	7,860	32·4	10,465	43·1	1,006	4·2	24,263
1919	9,193	37·8	13,179	54·3	1,832	7·5	85	0·3	24,289
1920	13,487	41·0	12,377	37·6	4,880	14·8	2,152	6·5	32,896
1921	6,168	26·1	11,047	46·7	5,703	24·1	714	3·0	23,632
1922	4,750	18·7	9,710	38·2	10,518	41·3	471	1·8	25,449
1923	3,217	14·3	6,088	27·1	12,384	55·2	737	3·3	22,426
1924	2,329	10·5	4,998	22·6	13,516	61·2	1,255	5·7	22,098
1925	1,745	7·6	3,566	15·5	16,149	70·4	1,486	6·5	22,946
1926	1,264	6·6	3,052	15·9	13,808	71·9	1,085	5·6	19,209
1927	1,411	6·4	3,451	15·7	16,136	73·3	1,021	4·6	22,019
1928	1,286	6·0	3,156	14·9	15,957	75·1	844	4·0	21,243
1929	1,229	5·9	2,727	13·1	15,655	75·2	1,200	5·8	20,811
1930	1,229	6·3	2,864	14·8	14,031	72·4	1,258	6·5	19,382
1931	1,091	6·1	3,374	18·8	12,757	70·9	762	4·2	17,984
1932	1,078	6·7	3,438	21·4	10,661	66·4	875	5·5	16,052
1933	1,237	7·0	3,637	20·5	12,641	71·3	211	1·2	17,726
1934	1,292	7·0	3,864	21·1	13,065	71·2	128	0·7	18,349
1935	1,181	7·3	3,379	20·8	11,659	71·6	64	0·4	16,283
1936	907	5·5	2,886	17·6	12,498	76·4	71	0·4	16,362
1937	947	6·0	2,838	18·1	11,860	75·5	60	0·4	15,705

post-war categories cannot be regarded as at all comparable. (See Thursby-Pelham 10 p. 14).

Before the war the quantity and proportion per cent of "Large" fell steadily; "Medium" tended to rise in actual quantity and rose markedly proportionately, while "Small" after an initial rise, fluctuated. The decrease in total landings was due almost entirely to the decline in "Large".

When, after the war the sorting had changed, part of the fish that were formerly included in "Large" were classed as "Medium", and some of the "Medium" were included in "Small". As already mentioned, when hostilities ceased the North Sea was found to be teeming with "Large" and "Medium" fish while "Small" were scarce. The position was very soon reversed and for the last 13 years "Small" have made up over 70 % of the landings. The statistical category "Small", however, at Lowestoft and Grimsby, (the two principal North Sea plaice ports) includes fish up to 38—40 cm. If, therefore, the landings consisted mainly of the sub-divisions of "Small" which include the larger sizes, there would be no evidence of a harmful decrease in size. However, detailed statistics which have been obtained at the two ports show a steady rise in the proportions of the categories of the smaller fish and a decline in those consisting of the larger fish. These detailed statistics have been obtained at Lowestoft since 1929, and at Grimsby since 1934. In addition, samples of each trade category have been weighed, measured, otolithed and the samples raised to the total landings and landings per 100 hours' fishing four times each year. This work began in 1929 at Lowestoft and 1931 at Grimsby.

The landings of each category per 100 hours' fishing at Lowestoft are given in Table 9, and illustrated in Figure 5.

At this port, however, much alteration has taken place in the sorting of fish after the enforcement of minimum size limit of 9 inches in August 1933, as an appreciable quantity of plaice below that size were previously landed. Again, owing to the scarcity of better sized fish "Small" were subdivided in 1935 and another category added of "Good Small", which are included with the "Best Small". From July, 1937, yet another sub-division — "Small Blue Cross" — was made and these are also included in "Small". The following table shows how the sorting has altered.

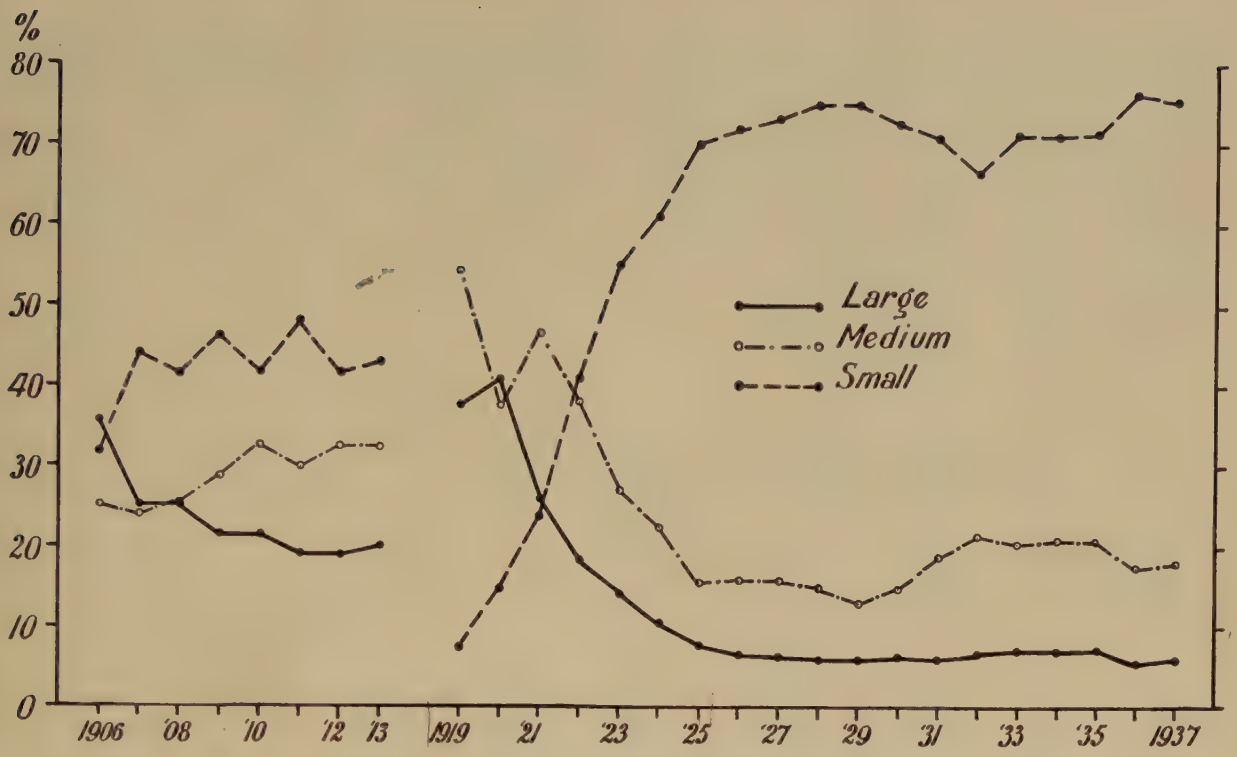


Fig. 6. Proportion per cent. of "Large", "Mediums", and "Small" Plaice landed by all British vessels at English ports 1906—1913, and 1919—1937.

Table 9.

Landings of Plaice (cwt.) per 100 hours' fishing at Lowestoft by 1st Class English Steam Trawlers.

	1929	1930	1931	1932	1933	1934	1935	1936	1937
Slabs, Large, Best..	2·2	2·2	2·1	2·2	2·3	2·8	2·6	2·7	2·7
Best Medium	1·9	1·4	1·3	1·2	1·1	1·1	1·0	1·0	1·0
Small Medium	2·2	1·6	1·3	1·2	1·1	0·9	0·6	0·7	0·7
Best Small	6·3	4·6	3·5	2·4	4·6	4·3	2·6	2·6	3·4
Small	25·8	21·9	14·4	7·5	13·2	10·6	5·8	4·4	11·6[1])
Dead Small	1·9	2·7	8·2	14·8	5·6	8·5	15·7	17·3	11·3
Total	40·3	34·4	30·8	29·3	27·9	28·2	28·3	28·7	30·7

[1]) Includes Small Blue Cross from July—December, 1937.

Table 10.

Average Size (mean) in Centimetres of each Trade Category of Plaice as sorted at Lowestoft in various periods.

	Slabs, Large and Best	Best Medium	Small Medium	Best Small	Good Small	Small Blue X	Small	Dead Small
1929—1932	45+	41—42	37—38	33—34			27	23
1936	46·6	42·0	39·6	37·8	35·9		32·8	26·9
1937 Jan.—June ...	47·2	41·2	39·1	37·5	35·0		32·4	27·0
1937 July—Dec. ..	44·6	41·1	38·3	36·5	34·7	31·7	28·0	25·1

Even taking all these differences into account there has certainly been a decline in the quantity of fish of the better categories.

The quarterly measurements and weighings are too voluminous to be shown here in detail, but the data for each October are typical of the other months. The proportion of each category by number shows more clearly than the figures by weight, the gradual decline of all fish above "Small" with the exception of "Slabs", "Large" and "Best" which has remained fairly constant with a very low percentage.

The figures for Grimsby for the landings per 100 hours' fishing are not so striking, but the trend is the same, a greater quantity of the smallest fish and a gradual diminution of the larger sizes. Sorting has varied little during the period of investigations, as few fish were landed below 9 inches prior to the enforcement of the size limit. Supplies also have been better maintained owing to the greater number of vessels and their wider area of fishing.

Table 11.

Proportion per cent. by Number of each Trade Category of Plaice landed at Lowestoft during October in the years 1929—1937, by 1st Class Steam Trawlers.

	Slabs Large and Best	Best Medium	Small Medium	Best Small	Small	Dead Small
1929	0·7	2·2	3·0	12·4	67·5	14.2
1930	0·4	0·8	1·3	4·7	75·8	17·0
1931	0·4	1·0	1·0	3·3	33·7	60·6
1932	0·5	0·8	1·3	2·7	15·4	79·3
1933	1·3	1·6	1·7	11·1	44·8	39·5[1])
1934	1·0	1·1	1·2	4·7	32·3	59·7
1935	1·3	1·2	1·4	5·6[2])	11·8	78·7
1936	0·9	1·2	1·4	4·0[2])	9·5	83·0
1937	0·8	1·0	1·1	5·0[2])	44·7[3])	47·4

[1]) Resorting from August 1933.
[2]) Includes Good Small.
[3]) Includes Small Blue X.

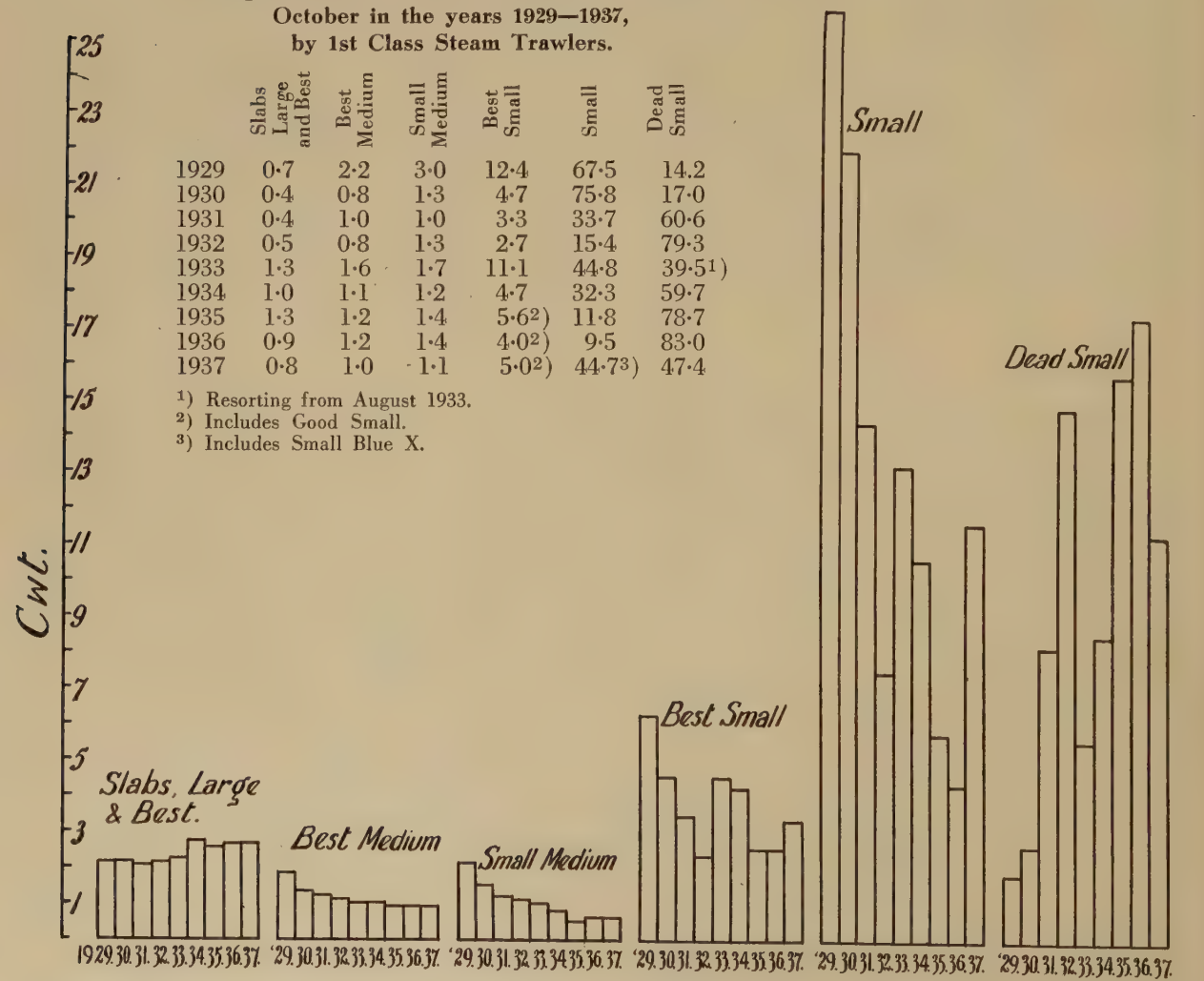


Fig. 7. Landings per 100 hours' fishing of 1st class British Steam Trawlers of each Trade Category of Plaice at Lowestoft 1929 to 1937.

Table 12.

Landings (cwt.) per 100 hours' fishing by 1st Class Steam Trawlers of each Trade Category of Plaice at Grimsby.

		Large	Large Best	Best Medium	Middles	Big Small	Small	Chats	Totals
March	1931.....	1	1¾	2	2¼	3½	2¾	5¾	19
	1932.....	1¼	2	2	2	3½	3¼	5	19
	1933.....	1	1¾	2	2½	3½	3¾	6	20½
June	1931.....	1	1¾	2½	2¾	4¾	3¾	6½	23
	1932.....	1	1½	2	2¼	4	4¼	8	23
	1933.....	¾	1¼	1¾	2	3½	4¾	10¾	24¾
Sept.	1931.....	¾	1½	2	2¼	3½	3½	5½	19
	1932.....	1	1½	2	2½	3¼	4	5¾	20
	1933.....	¾	1½	2	1¾	3¼	4¼	8	21½
Dec.	1931.....	1½	2¼	2½	2¾	3¼	3	3¾	19
	1932.....	1¾	2½	2¼	2½	2½	2¾	2¾	17
	1933.....	1¼	1¾	2	2	2½	2½	4	16
Year	1934.....	1·0	1·5	1·8	2·1	2·9	4·0	7·3	20·6
	1935.....	1·1	1·5	1·6	2·0	2·9	4·1	7·5	20·8
	1936.....	0·9	1·2	1·5	1·8	2·8	4·5	9·4	22·2
	1937.....	1·1	1·3	1·6	1·8	2·9	4·2	9·5	22·5
Average size (mean) cm. 1937		53·6	48·0	43·5	40·0	36·4	32·7	27·1	

As at Lowestoft the proportions per cent by number show the changes more forcibly. The following example for the month of September in the years 1931—1937 shows this very clearly.

Table 13.

Proportion per cent. by Number of each Trade Category of Plaice landed by 1st Class Steam Trawlers at Grimsby during September in the years 1931—37.

	Large	Large Best	Best Medium	Middles	Big Small	Small	Chats
1931	0·9	2·1	4·3	6·1	13·1	18·9	54·7
1932	0·8	1·9	3·4	6·1	12·8	25·8	49·2
1933	0·8	2·2	3·6	4·3	10·6	21·2	57·3
1934	0·8	1·9	3·0	5·5	9·6	20·6	58·6
1935	0·5	1·1	1·8	3·4	8·4	16·6	68·2
1936	0·5	1·2	1·9	3·4	8·3	20·9	63·8
1937	0·6	1·1	1·9	3·2	7·3	19·4	66·4

These examples are sufficient to show that during the last 7 years the average size of the North Sea plaice stock has gradually been getting smaller.

Further evidence is given in the number landed per 100 hours' fishing of mature and immature plaice at Lowestoft each December since 1927. For the purpose of these calculations female plaice of over 35 cm. and male plaice of over 30 cm. are regarded as mature.

Table 14.

Number landed per 100 hours' fishing of mature and immature male and female Plaice at Lowestoft by 1st Class Steam Trawlers, 1927—1937.

December	Mature ♀	Mature ♂	Immature ♀	Immature ♂	Total
1927	688·1	936·6	811·2	1,241·1	3,678
1928	681·3	975·8	736·5	399·4	2,793
1929	614·4	692·3	795·3	1,222·0	3,324
1930	405·1	534·6	860·8	525·5	2,326
1931	540·3	395·6	1,145·2	731·9	2,813
1932	308·5	252·7	503·9	3,599·9	4,665
1933	316·1	652·8	1,366·6	1,543·5	3,879
1934	340·5	398·8	1,194·5	1,090·2	3,024
1935	512·5	475·1	909·1	667·3	2,564
1936	367·4	447·5	1,220·8	759·3	2,795
1937	357·8	659·4	1,638·8	1,110·0	3,766

Marked fluctuations in the abundance of year-classes cause considerable alteration in the abundance of plaice from time to time and have led to an occasional brief improvement in the number of mature fish, but no very abundant year-class has been sufficient to check more than temporarily the steady fall in the number of female plaice of over 35 cm. nor of the males about 30 cm. The figures speak for themselves and need no further comment.

D. The Rate of Mortality estimated from the Age-Composition of the Plaice landed by Lowestoft Steam Trawlers 1929—37.

The long series of observations on the age-composition of the landings carried out on the market at Lowestoft four times a year are confusing to follow and so make it difficult to draw conclusions. The effects of the migrations in Spring of the young stock and of the spawning migrations in December, inevitably caused both the proportions and the number landed per 100 hours' fishing of each age-group to differ in the various months. It therefore, was necessary to compare the figures of the same months together year by year; those for all Aprils, all Julys and so on, and in consequence it was difficult to see the whole picture clearly. In order to obtain a clearer view, calculations based on the seasonal figures have been made, so that approximate annual figures can be given. This has been done by applying the proportions in the months when samples were obtained of each age-group in each trade category to the landings per 100 hours' fishing of each trade category in the succeeding months when no samples were taken. Thus the landings for May and June were apportionated as in April; August and September as in July; November as in October and January, February and March as in December. Since the conventional "birthday" of plaice is April 1st, the figures for each age-group were calculated from April 1st to March 31st in each year. Admittedly wide assumptions have been made but, since the abundance of the various year-classes as calculated by this method show for the whole year approximately the same variation from one to another as they did from an examination of the seasonal figures, the method may be said to provide a fair interpretation of the data.

In the estimation of the landings of the II, III and IV age-groups there have been difficulties to contend with. In Table 9 it can be seen that the quantity landed per 100 hours' fishing of the category "Dead Small" rose and fell very considerably from 1930 to 1933 and that these rises and falls coincided with the falls and rises of the category "Small". This did not mean however, that there was necessarily a scarcity of the fish of the early age-groups which are included in "Dead Small", but that when fish of the sizes included in "Small" were scarce, more of the "Dead Small" were landed instead of being rejected at sea, in order to fill up the holds. In August 1933, the size limit of 23 cm. was enforced, which also affected the number landed of the younger age-groups. In order to minimize the effect of these various factors so as to be able to obtain comparable data for the whole period, the figures have been re-calculated and all fish below 23 cm. have been omitted from April 1929 to July 1933. Table 15 therefore, is concerned only with plaice of 23 cm. or more.

Table 15.

The Number of Plaice landed per 100 hours' fishing by 1st Class Steam Trawlers at Lowestoft in each Age-Group. Fish under 23 cm. omitted. Years of Birth in Italics.

April 1st to March 31st.		Age-Groups II	III	IV	V	VI	VII	VIII	IX	X	XI+	Total
1929	1930	328 *'27*	2,120 *'26*	2,783 *'25*	1,128 *'24*	370 *'23*	768 *'22*	237 *'21*	112 *'20*	48 *'19*	56	7,950
1930	1931	223 *'28*	2,246 *'27*	1,938 *'26*	1,620 *'25*	302 *'24*	106 *'23*	181 *'22*	58 *'21*	18 *'20*	38	6,730
1931	1932	95 *'29*	2,898 *'28*	3,017 *'27*	1,150 *'26*	591 *'25*	116 *'24*	100 *'23*	82 *'22*	33 *'21*	37	8,119
1932	1933	77 *'30*	606 *'29*	4,385 *'28*	1,186 *'27*	231 *'26*	138 *'25*	42 *'24*	21 *'23*	51 *'22*	57	6,794
1933	1934	50 *'31*	489 *'30*	1,121 *'29*	4,738 *'28*	456 *'27*	106 *'26*	80 *'25*	27 *'24*	18 *'23*	58	7,143
1934	1935	44 *'32*	475 *'31*	1,666 *'30*	1,538 *'29*	2,510 *'28*	160 *'27*	50 *'26*	43 *'25*	14 *'24*	62	6,562
1935	1936	131 *'33*	1,373 *'32*	1,595 *'31*	1,587 *'30*	1,326 *'29*	883 *'28*	144 *'27*	30 *'26*	28 *'25*	68	7,165
1936	1937	38 *'34*	691 *'33*	2,862 *'32*	1,094 *'31*	864 *'30*	382 *'29*	436 *'28*	27 *'27*	15 *'26*	49	6,458
1937	1938	138 *'35*	1,293 *'34*	1,804 *'33*	1,810 *'32*	426 *'31*	390 *'30*	163 *'29*	228 *'28*	26 *'27*	56	6,334
Average number in each age-group 1929 to 1938		125	1,355	2,352	1,761	786	339	159	70	28	53	7,028

From the averages of the whole period it will be realised that the majority of the fish of the II and III age-groups are still below marketable size and that the maximum number are landed in the IV-group; thereafter the number is reduced in each subsequent year of life. The increases and reductions from one age-group to another are as follows:—

The figures show that, whether a year-class reached its maximum at an early or late age, the percentage number of fish available for capture after it has been subjected to four years' fishing is not very different. For example, the maximum number of fish of the 1926, 1927 and 1928 year-classes were landed when they were in the III, IV and V age-groups respectively, yet in each case the

Table 16.

The Percentage increase or reduction in the landings per 100 hours' fishing from one age-group to the next, based on the average of April 1929 to March 1938.

II-III	III-IV	IV-V	V-VI	VI-VII	VII-VIII	VIII-IX	IX-X
+984·0	+73·6	—25·1	—55·4	—56·9	—53·1	—56·0	—60·0

The reduction in numbers is rapid and it is perhaps more clearly shown from the percentage decline in the number landed in each successive year of 100 fish in IV group:—

Table 17.

Age-groups.	IV	V	VI	VII	VIII	IX	X
Years after IV-groups	—	1	2	3	4	5	6
Percentage of IV-group	100	75	33	14	7	3	1

This rate of reduction, however, is based on the average period of nine years, and the stock of fish in these nine years included fish produced from more than fourteen spawning seasons. The brood from each year's spawning varies widely in two ways. First in the number of survivors, and this is capable of very great fluctuations — and secondly in the rate of growth of the individual year-classes. The magnitude of these variations will be shown later. For the moment let us consider the effect of growth. Since fish do not become marketable till they have reached a certain size, it is inevitable that a slow growing year-class will not be present in its maximum numbers in the landings at as early an age as the products of a quickly growing year-class. In Table 15, for example, it will be seen that the 1926 year-class, which grew exceptionally rapidly, was landed in its greatest numbers in the III-group, while the 1928 and 1929 year-classes, which grew much more slowly, did not reach their maximum number till in the V-group. Consequently the rate of reduction from one age-group to another of the 1926 year-class differs greatly from that of the 1928 and 1929 year-classes. Owing to these variations in the individual year-classes, it is not possible to show whether there has been any change in the rate of mortality during the past nine years. These difficulties are best illustrated by comparing the percentage rate of reduction, year by year of individual year-classes, taking as the starting point the time when each appeared in its maximum abundance. (Table 18.)

percentage number landed 4 years later was 5. This table also appears to indicate that the rate of reduction of the individual year-classes is more rapid than that shown by all year-classes combined.

E. Variations in the Average Size and Abundance of Plaice spawned in different years.

The estimation of the magnitude and effect of fluctuations in abundance of different year-classes of plaice is so bound up in the variations of their rate of growth that the one cannot be discussed without the other.

We will deal first with the differences in growth. These can be shown in two ways, by comparing either the average length or the average weight per fish of the individual year-classes at different ages, since the weight of fish is dependant on their length. The two methods show the same features but the differences are perhaps more clearly shown by comparing the average weights. The data are voluminous and confusing when the whole material of observations carried out in the four months of each year for a period of nine years is studied.

Table 18.

Percentage rate of reduction of certain year-classes in the successive years from the time each was present in its maximum strength. (Age-group of maximum in brackets).

Year-Classes	Maximum	Years after maximum 1st	2nd	3rd	4th	5th	6th
1925	100 (IV)	58	21	5	3	2	1
1926	100 (III)	91	54	11	5	2	1
1927	100 (IV)	39	15	5	5	1	1
1928	100 (V)	53	19	9	5		
1929	100 (V)	86	25	11			
1930	100 (IV)	95	52	23			
1931	100 (IV)	69	27				

Table 19.

The mean average weight in grammes of plaice of certain year-classes landed by 1st Class Steam Trawlers at Lowestoft, based on the average weights of the fish landed in July, October and December from 1929 to 1937. (Fish below 23 cm. in length omitted).

Age-Groups	Year-Classes											
	1933	1932	1931	1930	1929	1928	1927	1926	1925	1924	1923	1922
IV	222	194	207	183	184	184	233	257	220			
V		305	252	266	204	232	266	332	340	270		
VI			354	332	295	256	369	373	423	441	319	
VII				484	361	356	519	504	506	497	498	392

The results have therefore been summarised (table 19) by adding together the average weight of the fish landed in the IV to VII age-groups in July, October and December in each year and dividing by three, thus obtaining the mean weight of each year-class as it appears in each of these four age-groups. Unfortunately the data obtained in each April had to be omitted as insufficient material was obtained in April 1935 to give reliable figures.

These figures have been plotted in Fig. 8.

The most salient features of the graphs are the comparatively high average weights of the 1925 to 1927 year-classes and the very low averages of the 1928 and 1929 year-classes. Those spawned from 1930 to 1932 show a gradual up-ward trend.

These marked differences in growth between the year-classes are evidently common to the North Sea stock as a whole, and not only to that of the more southern part fished by the Lowestoft vessels. This is shown by the striking similarity in the higher and lower sizes of the same age-groups obtained from the Grimsby investigations. These were carried out in each June, September, December and March from June 1932 to March 1938. The mean weights have been calculated in the same way as those for the Lowestoft landings but in this case all the figures for the four months of each year have been utilised. The data are given in Table 20 and plotted in Fig. 9.

Fig. 8. Mean average weight (grammes) of certain Year-Classes of Plaice in the IV—VII age-groups landed by 1st class Steam Trawlers at Lowestoft. Fish below 23 cm. omitted.

Table 20.

The mean average weight in grammes of plaice of certain year-classes landed by 1st Class Steam Trawlers at Grimsby, based on the average weight of the fish landed from June 1931 to March 1938.

Age-Groups	Year-Classes									
	1933	1932	1931	1930	1929	1928	1927	1926	1925	1924
IV	220	212	222	222	193	183	213			
V		313	270	290	244	249	331	354		
VI			412	370	324	290	402	465	442	
VII				503	421	402	516	554	554	499

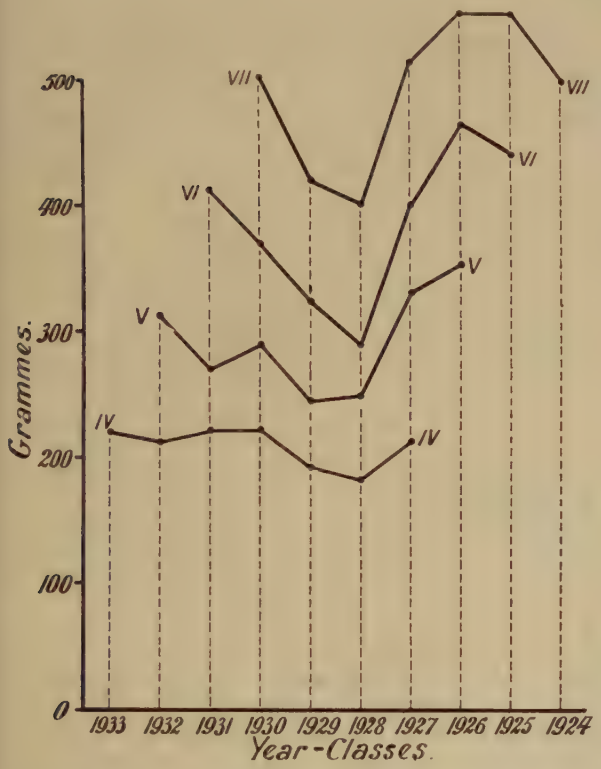


Fig. 9. Mean average weight (grammes) of certain Year-Classes of Plaice in the IV—VII age-groups landed by 1st class Steam Trawlers at Grimsby.

The degree of correspondence between the two series of graphs is remarkable when it is realised that the samples are collected at random at both ports and comprise fish taken from a very wide area.

Fluctuations in Abundance.

As already mentioned the figures in Table 15 showed that the numbers of fish surviving from the spawning of different seasons vary considerably. While there is no difficulty in seeing that the stock spawned in 1928 was outstandingly abundant since it outnumbers every other year-class from the III-group onwards, it is not so easy to estimate the relative strength of the remainder owing to their different rates of growth. For example, if the 1924 to 1932 year-classes are compared when all are in the V-group, a widely different ratio would be found if the comparison was made on the III or IV age-group. One way of getting over the difficulty is to calculate the ratio of each year-class relative to 1928 taking as a basis in each case the age when it was present in its maximum numbers. This is shown in Table 21.

This method is open to the criticism that it unduly depresses the proportions of those year-classes which were represented in their maximum numbers at a late age, since although many were too small to be *landed* when younger, they were, nevertheless affected by the mortality due to fishing since they would be caught and rejected. The usual methods in practice on board Steam trawlers do not give the under-sized fish any great chance of survival.

Another method is to take the total numbers landed of each year-class once a period of years and so estimate the actual yield in marketable fish. In this way the yield of the year-classes 1925 to 1932 may be dealt with. Although the actual landings of the 1925 year-class in the III-group is unknown and similarly those of the 1931 in the V and 1932 in the V and VI age-groups, we can estimate them by applying to the existing data the average rates of increase or decrease from one age-group to another given by Table 16, p. 57. The results are given in Table 22.

These calculations show considerably lower ratios relative to the 1928 year-class than those given in Table 21. Though neither method can give an exact estimate of the relative strength of the different broods, it is probable that the figures in Table 22 are nearer the mark. This is borne out to some degree by the landings by weight per 100 hours' fishing shown in Table 23 and illustrated by the histograms in Fig. 10. Unfortunately the yearly landings by weight have only been estimated from April 1931 and therefore do not include the results of the investigations of the two previous years which have been calculated for number alone.

The histograms show clearly how greatly the

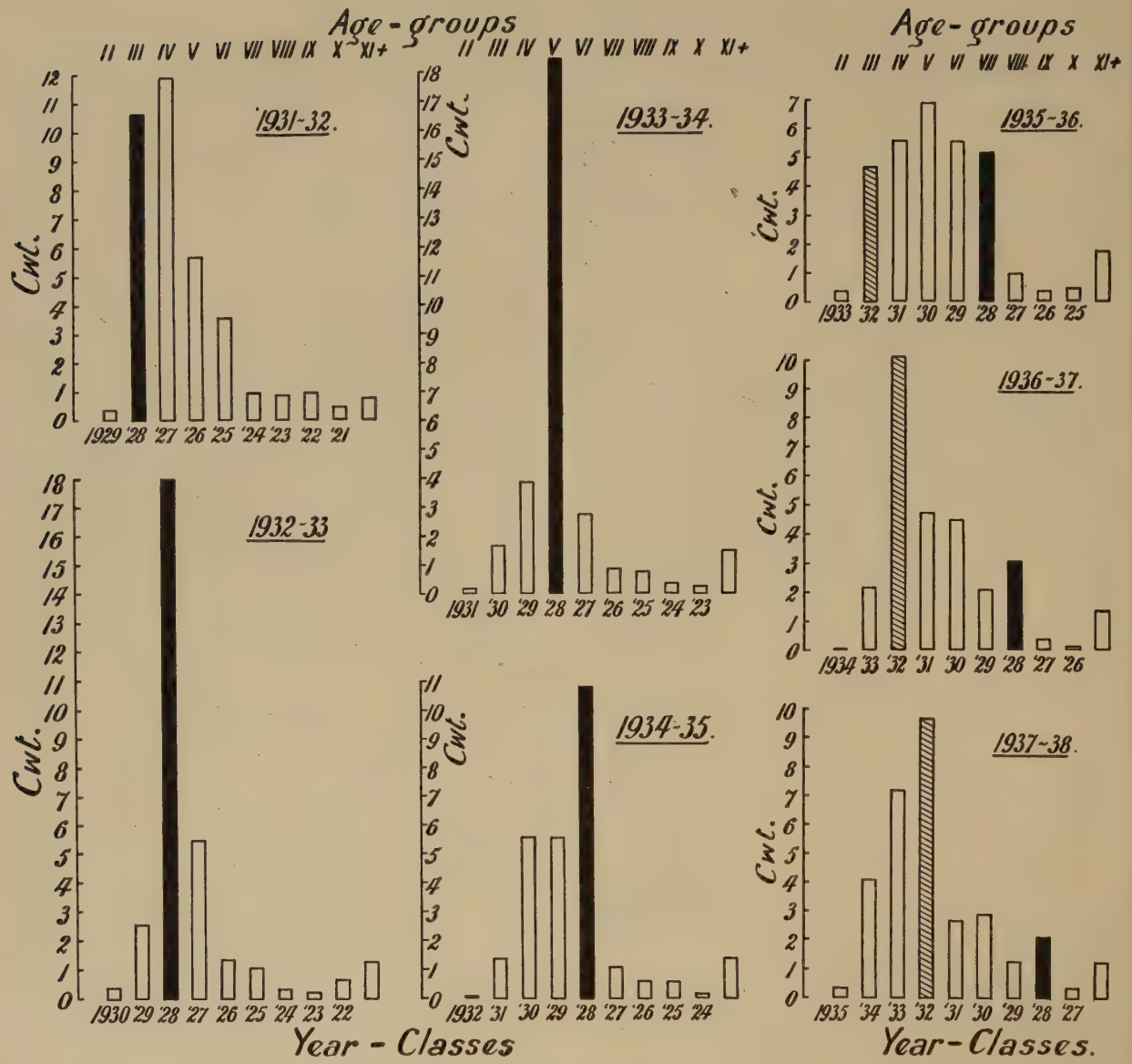


Fig. 10. Landings (cwt.) per 100 hours' fishing of each Age-Group of Plaice by 1st class Steam Trawlers at Lowestoft, April 1st 1931 to March 31st 1938.

Table 21.

Landings per 100 hours' fishing of Year-Classes 1925 to 1933 by 1st Class Steam Trawlers at Lowestoft, when each was present in its maximum abundance. Fish below 23 cm. omitted.

	Year-Classes								
	1925	1926	1927	1928	1929	1930	1931	1932	1933
Landings per 100 hours fishing ..	2783	2120	3017	4738	1538	1666	1595	2862	1804
Age-groups	IV	III	IV	V	V	IV	IV	IV	IV
Relative Abundance expressed as percentage of the 1928 year-class	59	45	64	100	32	35	34	60	38

Table 22.

Estimated Number of Plaice landed per 100 hours' fishing by 1st Class Steam Trawlers at Lowestoft of the 1925 to 1932 Year-Classes in the III—VII Age-groups. Fish below 23 cm. omitted.

	Year-Classes							
	1925	1926	1927	1928	1929	1930	1931	1932
Numbers	6,735	5,545	7,065	15,414	4,973	4,996	3,774	7,200
Ratio expressed as % of 1928 year-class	44	36	46	100	32	32	24	47

Table 23.

Cwt. landed per 100 hours' fishing of each Age-Group at Lowestoft by 1st Class Steam Trawlers in each year April 1st – March 31st from April 1931 – March 1938. (Includes plaice below 23 cm.) Year-Classes in Italics.

April 1st to March 31st		II	III	IV	V	VI	VII	VIII	IX	X	XI+	Total
1931	1932	0·4	10·6	11·9	5·7	3·6	1·0	0·9	1·0	0·5	0·8	36·4
		'29	*'28*	*'27*	*'26*	*'25*	*'24*	*'23*	*'22*	*'21*		
1932	1933	0·4	2·6	18·0	5·5	1·4	1·1	0·4	0·3	0·7	1·3	31·7
		'30	*'29*	*'28*	*'27*	*'26*	*'25*	*'24*	*'23*	*'22*		
1933	1934	0·2	1·7	3·9	18·4	2·8	0·9	0·8	0·4	0·3	1·5	30·9
		'31	*'30*	*'29*	*'28*	*'27*	*'26*	*'25*	*'24*	*'23*		
1934	1935	0·1	1·4	5·6	5·6	10·8	1·1	0·6	0·6	0·2	1·4	27·4
		'32	*'31*	*'30*	*'29*	*'28*	*'27*	*'26*	*'25*	*'24*		
1935	1936	0·4	4·7	5·6	6·9	5·6	5·2	1·0	0·4	0·5	1·8	32·1
		'33	*'32*	*'31*	*'30*	*'29*	*'28*	*'27*	*'26*	*'25*		
1936	1937	0·1	2·2	10·1	4·7	4·5	2·1	3·1	0·4	0·2	1·4	28·8
		'34	*'33*	*'32*	*'31*	*'30*	*'29*	*'28*	*'27*	*'26*		
1937	1938	0·4	4·1	7·2	9·7	2·7	2·9	1·3	2·1	0·4	1·3	32·1
		'35	*'34*	*'33*	*'32*	*'31*	*'30*	*'29*	*'28*	*'27*		

1928 year-class dominated the landings from 1932 to 1934. There is in fact much that can be gathered from an examination of these diagrams if at the same time what has been stated in the immediately previous pages on the rate of mortality, fluctuations in abundance and variations in growth rate are borne in mind. It will be seen that they show pictorially the effect of all these factors on the landings year by year.

They show, too, that the greater part of the landings by weight are of fish in the IV to VI age-groups. Over the whole period, the average of these three age-groups combined account for 68 % of the total landings. A comparison on Table 24 made of the total yield of the 1927 to 1931 year-classes by weight of the IV, V and VI age-groups gives a ratio which differs very slightly from that obtained by number, shown in Table 22.

Before leaving these attempts at estimating the relative strength of year-classes at the ages when they were present in their greatest quantity, both by number and weight in landings, mention must be made of the earlier year-classes who had, so to speak, passed their prime, and therefore cannot be

Table 24.

Landings (cwt.) per 100 hours' fishing of the 1927 to 1931 year-classes in the IV—VI age-groups by 1st Class Lowestoft Steam Trawlers.

	Year-Classes				
	1927	1928	1929	1930	1931
Cwt. landed IV, V and VI age-groups	20·2	47·2	15·1	16·8	13·0
Ratio as % of the 1928 year-class	43	100	32	36	28

assessed in this way. Earlier investigations made on the market at Lowestoft enabled the writer to make the following summary (Thursby-Pelham, 10, p. 42.) "the 1920, 1921 and 1922 broods may be classed as good, and on this basis the 1923 and 1924 results were poor. The 1925 year-class has already been estimated to be about half that of 1922." Reference to Table 15 will show that in the VII to X age-groups — the 1920 to 1922 year-classes — gave higher landings per 100 hours' fishing than any other year-classes

except that of 1928 and so confirms the statement quoted above. While it is not possible to be positive, the estimation of the relative strength of the 1925 year-class was probably unduly optimistic.

F. The Effect of Fluctuations in Abundance on the landings per 100 hours' fishing of the different categories of Plaice at Lowestoft.

In order to show all the effects of the fluctuations in abundance and variations in the growth rate of the different year-classes on the landings of the various trade categories as sorted on Lowestoft market, it would be necessary to go into so much detail that the main issues would be obscured. This is due to the wide range of size of plaice of any age-group and of any year-class. Plaice of the IV-group and over may be present in all the categories from "Dead Small" to "Large".

However, the more marked changes shown in Figure 7, can be correlated with the presence or absence of abundant year-classes.

As already stated there has been a general downward trend in all categories except that consisting of "Slabs, Large and Best" and of "Dead Small". These however, do not concern us in this discussion. "Large" are made up of so many different ages that it is not possible to draw any conclusions, while the landings of "Dead Small" cannot be compared, as they have been so much affected both by market requirements and by the enforcement of the size limit.

Best Medium.

The high level in 1929 — more than in any succeeding year —, was due to the rich year-classes of 1920 to 1922. As their yield from these year-classes was decreased by mortality, the landings fell, since the amount contributed by the 1923 to 1927 year-classes was not sufficient to keep up the supply. The decline was checked from 1935 to 1937 by the presence of the 1928 year-class.

Small Medium.

The reasons for the decline of the landings of this category are much the same as for "Best Medium" up to 1933. Since then however, it is not possible to relate the decline entirely to the scarcity of fish of the right size, as the demand for this particular category has changed and it is now only sorted out to meet the requirements of individual firms.

Best Small.

Again the high level of the 1929 landings was due to the 1922 year-class and the succeeding year-classes were not sufficient to resist the inroads on the stock until, in 1933, the 1928 year-class sent up the abundance temporarily. The last small increase in 1937 is due to the 1932 year-class and also to the alteration in sorting when smaller fish were included in the category.

Small.

As already stated the landings in 1937 are not comparable with those of other years owing to the inclusion of smaller fish in that year.

From the biological aspect of over-fishing the very sharp drop between 1929 and 1936, only checked by the 1928 year-class in 1933 and 1934 is of particular interest. Even if no other data were available, the almost continuous decline is sufficient to show that there is an insufficient number of recruits to prevent a further decline in the plaice stock of the Southern North Sea under the present intensity of fishing.

Summary.

1. The historical evidence available indicate that the stock of plaice in the North Sea 46 years ago produced as great a total yield as now, but that the fish were of a much larger size than at the present time.
2. The changes in the methods of fishing during the last 46 years is discussed and it is shown that alterations in the gear used by English vessels have increased their efficiency and have reduced considerably the areas which formerly provided sanctuaries for plaice.
3. It is shown that a greater weight of plaice was landed by all nations combined between 1925 and 1930 than during any other period between the years 1906 and 1936. Since 1930 the landings have declined almost steadily and by 1935 were below the level of 1906 to 1913.
4. The difficulties of estimating changes in abundance from the evidence provided by the landings per day's absence from port or by the landings per 100 hours' fishing by British Steam trawlers is discussed. It is shown that, owing to increased efficiency of gear and the different distribution of vessels fishing for plaice, the figures give an erroneous impression. The undoubted decline in abundance of plaice, however, is shown by a series of charts. This decline is particularly noticeable in recent years on the more easterly grounds of the North Sea. Since these are the grounds inhabited by the young stock from which the general stock of North Sea plaice is recruited, the conclusion to be drawn is that the stock is over-fished to so great an extent that a further decline under the present intensity of fishing is inevitable.
5. The average size of plaice has also fallen. This began before the war, but was arrested when the North Sea had a partial rest during the period of hostilities. After the war the sea was well stocked with large plaice but the position was soon reversed and of recent years the

landings consist principally of fish of the smallest categories. This is shown in detail for the landings at Grimsby and Lowestoft. Evidence of a serious decrease in the abundance of spawning fish in the last 10 years is also given.

6. The rate of mortality is shown to be over 50 per cent. for plaice of the V age-group and over.
7. It is shown that fluctuations in the survival of brood and variations in the growth-rate of different year-classes have a considerable effect on the landings of plaice at Lowestoft. At the same time it is evident that, while an exceptionally strong year-class can check the downward trend both in abundance and in average size, its effect is only temporary and that normal recruitment of the stock is insufficient to withstand the inroads made upon it by the present intensity of fishing.

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6.

THE RATE OF MORTALITY OF THE HADDOCK OF THE NORTH SEA STOCK 1919–1938.

BY

D. S. RAITT.

Introduction.

THE geographical distribution of the haddock ranges from North America to north-western Europe and into the boreo-arctic reaches of the Atlantic area. Within the boundaries of its distribution it is not of general occurrence but is confined to certain definite locations. These are the banks and shallows of the coastline of North America from Cape Cod to Cabot Strait, the North Sea and contiguous grounds of the plateau of the continent of Europe, around the Faroe Islands, around Iceland, in certain parts of the Barents Sea and Bear Island region, in the shallows of the Romsdal Bank region of Norway, and on the isolated Rockall Bank off the west of Scotland.

There is no continuity of occurrence between these different regions. Beyond the limit of, approximately, the 200 metre depth contour, in each separate area, the species is not found.

In all areas in which the haddock is present it is known to spawn, and prevailing current systems are such as to retain the products of spawning within the region of their origin and to preclude probability of interchange of stock by surface drift from one area of occurrence to another.

All available evidence points to the conclusion that throughout the North Atlantic and seas offset therefrom there exists a number of independent populations of haddock, isolated from each other geographically and bathymetrically, each self-contained, and each self-supporting. In all stock surveys, due distinction must accordingly be made between these separate populations. The rate of depletion of the stock of the North Sea and adjacent waters of less than 200 m. deep is a field of study complete in itself and independent of consideration of any other area in which the species occurs.

Details of the literature bearing upon the existence of independent stocks of the species are included in the writer's earlier study of the brood fluctuations of the different haddock grounds of the north-east Atlantic (Raitt, 1936).

Data.

During the past 20 years the Scottish Fishery Board has conducted continuous research upon the haddock stock of the North Sea region.

Investigations have been based upon the results of the trawling operations of the research ship "Explorer", the gear employed being a standard Otter Trawl fitted with an outer cod-end cover of small mesh shrimp netting to retain escapes from the normal mesh and secure representative sampling of all fish from smallest to largest on each ground surveyed.

Routine on board the "Explorer" consists, so far as the haddock is concerned, of recording the length, sex, and degree of maturity, and of taking a sample of the scales of each fish caught. The

Table

Frequencies Per 10 Hours' Fishing, Year Classes 1913 to 1936,

Year of Life \ Year-Class		1936	1935	1934	1933	1932	1931	1930	1929	1928	1927	1926	1925
First	0+	—	—	—	—	—	—	—	—	—	—	—	—
Second	1+	265	2094	250	699	318	1835	303	662	3511	308	1550	964
Third	2+	—	623	73	195	167	937	223	288	2760	249	1543	673
Fourth	3+	—	—	29	44	45	224	61	159	455	109	347	213
Fifth	4+	—	—	—	15	18	76	10	55	374	57	87	75
Sixth	5+	—	—	—	—	6	32	5	11	58	22	29	21
Seventh	6+	—	—	—	—	—	11	1	4	12	2	9	6
Eighth	7+	—	—	—	—	—	—	0·4	1·1	5	0·2	1·4	2·6
Ninth	8+	—	—	—	—	—	—	—	0·6	2·2	—	0·5	0·3
Tenth	9+	—	—	—	—	—	—	—	—	0·9	0·1	0·4	0·2
Eleventh	10+	—	—	—	—	—	—	—	—	—	0·1	0·1	0·1
Twelfth	11+	—	—	—	—	—	—	—	—	—	0·1	—	—

number of age-determinations of North Sea fish subsequently made ranges from twenty to thirty thousand per annum. The technique of scale reading is as established by Thompson, 1922.

Masses of data are thus obtained in the form of numbers of haddock of different ages in different locations at different times, from which may be calculated, as detailed by Thompson, 1929, the mean density in unit duration of fishing of each age-group encountered from year to year over the region as a whole. A table of such age-group frequencies was published by Thompson, 1929, covering the period 1919 to 1927. The present writer has already extended Thompson's results up to 1934 (Raitt, 1936). Figures for the years 1935 to 1937 are added herein, and are incorporated in Table 1 with the statistics already available.

The table is arranged, horizontally, according to year-class, and, vertically, according to age. The age-composition of the stock from year to year is read diagonally downwards from left to right. The average catch per 10 hours' fishing made by the "Explorer" throughout 1928, for example, consisted of 308 fish in their second year (hatched 1927), 1543 in their third (hatched 1926), 213 in their fourth (hatched 1925), and so on. Reading horizontally, comparisons of the numerical proportions of the different year-classes at equivalent ages, that is the brood fluctuations of the area, are obtained. In the second year of life, 3511 fish of the 1928 brood were taken as against only 308 of that of 1927 at the same age, 1550 of that of 1926, and so on. Reading vertically, the frequencies of each year-class encountered in successive years of life give the rate at which its ranks have become fished out. Of the brood of 1928, the average catch of 3511 fish in the second year of life was reduced to 2760 in the third, 455 in the fourth, and so on.

In compiling these frequency figures, the results obtained by the "Explorer" are subjected to verification by additional material from the Board's inshore research vessel, by scale samples and ichthyological data from kindred laboratories in other countries and by determination of the age-composition of commercial catches. Time has proved the reliability of the methods used and of the statistics obtained. It is a feature of the results that the initial numerical relationships found from brood to brood are corroborated year after year in subsequent life. The second-year frequencies found for the broods of 1922, 1923, and 1924, for example, were 49, 2806, and 1192 respectively. Year after year until it became fished out, the 1923 brood occurred in correspondingly superior numbers to that of 1924, and similarly with 1924 in relation to 1922. It has further been shown that the rise and fall in the frequencies found from brood to brood in early life are in close agreement with the subsequent rise and fall from year to year in the landings from the area by commercial fishing operations (Raitt, 1936a).

Table No. 1 incorporates the results of over half a million age-determinations of North Sea haddock.

Initial Recruitment.

With regard to assessment of initial recruitment by new broods, a modification of previous policy is here adopted. The haddock spawns in spring. The haddock year, for statistical purposes, is dated from 1st April to 31st March. Young haddock are at first pelagic and do not adopt bottom habitat until from about the fourth to about the sixth month of their first year of life. First-year frequency figures have to be based upon the results of trawl hauls taken over the second six months, October to March. Particularly in the case of broods which are poor in numbers, such restricted sampling sometimes results in discrepancies necessitating adjustment in terms of the frequencies found in the second and sustained in later years of life (Thompson, 1929). In the present issue it is

1.

Second to Twelfth Years of Life, North Sea Haddock.

1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	Year-Class / Year of Life	
—	—	—	—	—	—	—	—	—	—	—	—	First	0+
1192	2806	49	215	2183	1056	831	—	—	—	—	—	Second	1+
1153	2386	39	172	1685	750	766	382	—	—	—	—	Third	2+
464	851	16	86	909	315	136	136	272	—	—	—	Fourth	3+
122	353	13	30	410	131	89	56	113	—	—	—	Fifth	4+
33	55	10	30	149	82	20	28	72	—	—	—	Sixth	5+
7	11	3	23	64	59	15	7	6	4	—	—	Seventh	6+
1·7	1·6	0·1	1·8	31	10	10	5	5	0·6	5·6	—	Eighth	7+
1·1	0·4	0·1	0·4	2·8	3·3	0·4	3·4	1·0	0·3	0·2	2·0	Ninth	8+
0·1	0·3	—	0·1	0·5	0·2	0·9	0·4	0·7	1·0	0·2	0·3	Tenth	9+
0·5	—	—	0·03	—	—	—	—	—	—	—	—	Eleventh	10+
—	—	—	—	—	—	—	—	—	—	—	—	Twelfth	11+

of more practical value to discard these first-year figures, which are accordingly omitted from Table 1, and to base analyses upon those obtained over the full twelve months of the second year of life.

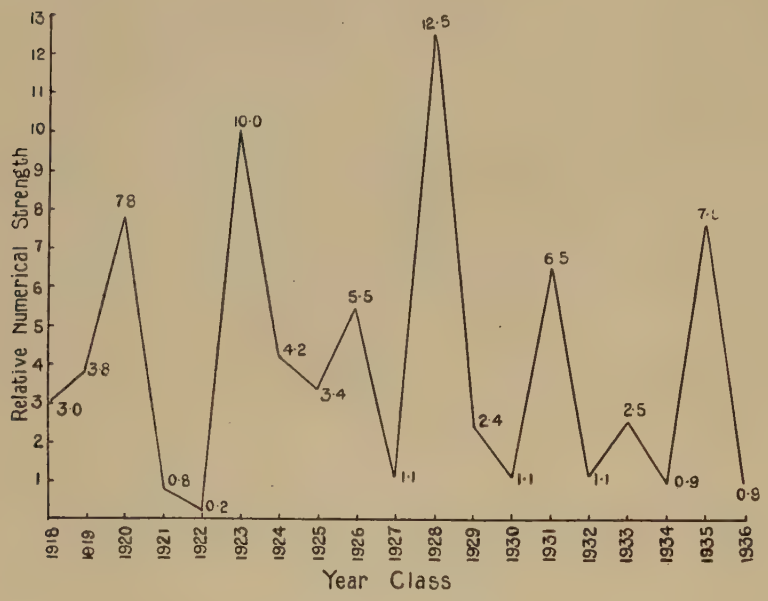

Fig. 1. North Sea Haddock Brood Fluctuations, 1919—1936. Second Year Relative Frequencies.

Figure 1 is the graph of the second-year brood frequencies of Table 1, that of 1923 rated at the figure 10 and the relative values of the remainder calculated proportionately. At the stage when they first came under the influence of the commercial trawl, North Sea haddock broods from 1918 to 1936 are shown to have been subject to violent fluctuations in numerical strength just as with the first-year statistics already in publication (R a i t t, 1936 and 1936a). There have been six broods of outstanding abundance, those of 1920, 1923, 1926, 1928, 1931, and 1935, seven broods of outstandingly inferior numerical order, 1921, 1922, 1927, 1930, 1932, 1934, 1936, and six of intermediate proportions, 1918, 1919, 1924, 1925, 1929, and 1933. During the ten years 1918 to 1927, there occurred three outstandingly good broods, four intermediate, and three outstandingly bad. During the nine years 1928 to 1936, there occurred three outstandingly good broods, two intermediate, and four outstandingly bad. Those which were highly successful occurred at intervals mostly of two years. The good brood of 1926, however, was followed by only one poor year before the next outstandingly abundant brood, that of 1928, and following 1931, there intervened two especially poor years and one intermediate before the next prolific brood, that of 1935. The latter half of the period in review has been marked by an increase in the frequency of occurrence of outstandingly poor broods, and, in consequence, a decrease in the average degree of annual recruitment.

Percentage Survival.

Table 2 is constructed from Table 1 by rating the second-year frequency of each brood at 100 and calculating the percentage of the initial second-year figure which the frequency of each subsequent year represents. Of the 1927 brood, for example, for every hundred caught in the second year of life, 81 were taken in the third, 35 in the fourth, 19 in the fifth, and so on.

Comparison of the third-year percentages of the different broods shows variation from 99 in that of 1926, to 28 in that of 1933. Similarly wide variations occur in the statistics pertaining to the other years of life. Figures 2 and 3 are the graphs of the percentages of Table 2, smoothed in threes. There can be no doubt as to their interpretation. In the case of the third-year graph, an increase in percentage survival is shown to have taken place from between about 75 and 80 in the broods of 1919 and 1920 to between about 85 and 90 in those of 1923 to 1925, that is between the fishing years 1920—1922 and those of 1925—1927. Subsequently there took place a severe and rapid decline to the level of about 30 $^0/_0$ survival in the fishing years 1935 to 1937. The remaining graphs all show corresponding increases in rate of survival in the opening years of the period up to about the fishing

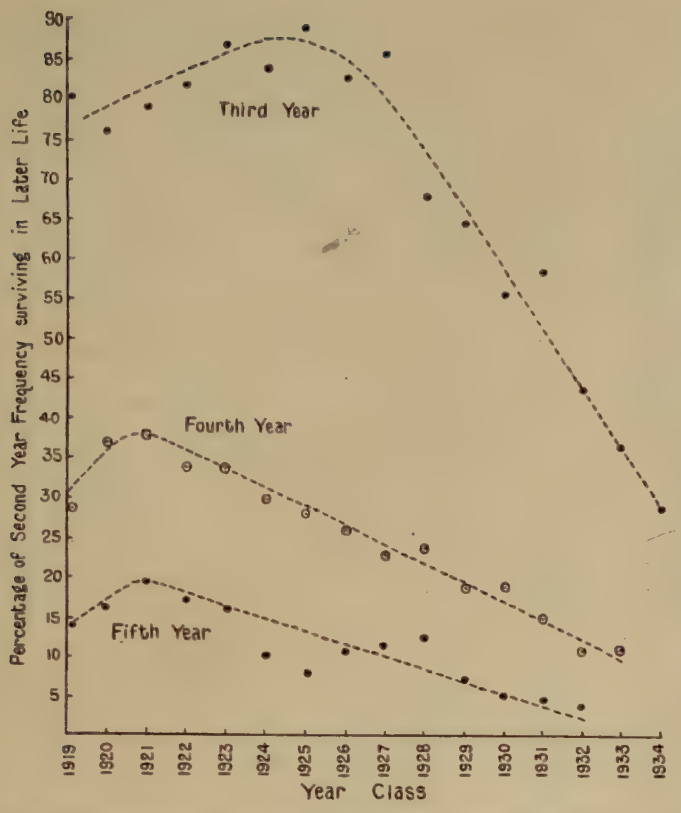

Fig. 2. Percentage Survival, Broods 1919—1934, 3rd, 4th, and 5th Years, North Sea Haddock.

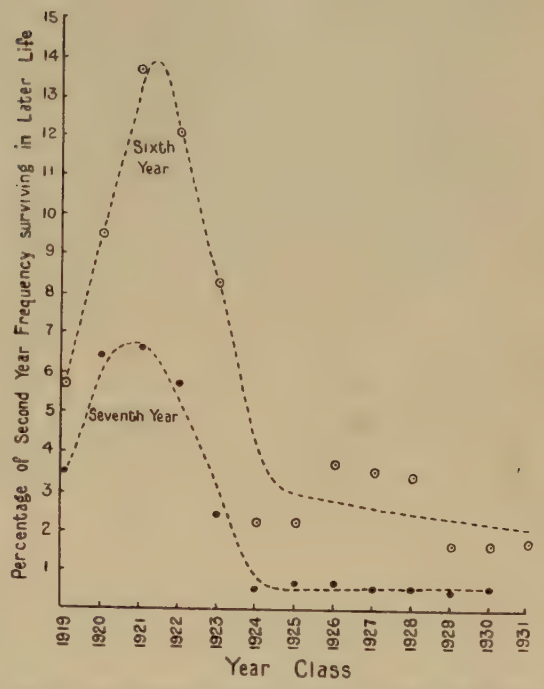

Fig. 3. Percentage Survival, Broods 1919—1931, 6th and 7th Years, North Sea Haddock.

Table 2.

Percentages of Second Year Frequencies Surviving in Later Life, North Sea Haddock Broods. 1918—1935.

Year Class	Percentages of Second Year Frequencies Surviving in Later Life. Third Year		Fourth Year		Fifth Year		Sixth Year		Seventh Year	
		Smoothed in Threes		Smoothed in Threes		Smoothed in Threes		Smoothed in Threes		Smoothed in Threes
1918	92		16		10·7		2·4		1·8	
1919	71	80	30	29	12·4	14·0	7·8	5·7	5·6	3·4
1920	77	76	42	37	18·8	15·1	6·8	9·5	2·9	6·4
1921	80	79	40	38	14·0	19·5	13·9	13·7	10·7	6·6
1922	80	82	33	34	25·6	17·4	20·4	12·1	6·1	5·7
1923	85	87	30	34	12·6	16·1	1·9	8·3	0·4	2·4
1924	97	84	39	30	10·2	10·2	2·7	2·2	0·6	0·5
1925	70	89	22	28	7·8	7·9	2·1	2·2	0·6	0·6
1926	99	83	22	26	5·6	10·7	1·9	3·7	0·6	0·6
1927	81	86	35	23	18·6	11·6	7·1	3·5	0·6	0·5
1928	78	68	13	24	10·7	12·5	1·6	3·4	0·3	0·5
1929	44	65	24	19	8·3	7·4	1·6	1·6	0·6	0·4
1930	74	56	20	19	3·3	5·2	1·6	1·6	0·3	0·3
1931	51	59	12	15	4·1	4·4	1·7	1·7	0·6	—
1932	53	44	14	11	5·7	4·0	1·8	—	—	—
1933	28	37	6	11	2·1	—	—	—	—	—
1934	29	29	12	—	—	—	—	—	—	—
1935	30	—	—	—	—	—	—	—	—	—

years 1925—1927, followed by severe declines. In the case of the 6th and 7th-year graphs, levels were reached about 1929—1930 suggestive of stray occurrences of odd specimens of broods which are practically fished out. Such isolated points as might be regarded out of line with the graphs indicated by the remainder serve to emphasise the striking agreement shown in the data as a whole.

The change in the rate of depletion in the past 15 years is indeed a severe one. During the period of greatest survival, that is the years 1925 to 1927, the brood of 1923 was in its third, fourth, and fifth years of life. The brood of 1933 was in its third, fourth and fifth years from 1935 to 1937. The smoothed curves of Figures 2 and 3 indicate that the percentage survival of the 1923 brood as compared with that of 1933 was, approximately:—

	3rd Year	4th Year	5th Year
1923	85	35	15
1933	35	10	1

The percentages eliminated at different ages were, approximately:—

	3rd Year	4th Year	5th Year	Remainder
1923	15	50	20	15
1933	65	25	9	1

Greatest toll was taken of the brood of 1923 in its fourth year. In that of 1933 greatest toll was taken in the third. The 1933 year-class was depleted by the end of its third year to the extent of two-thirds of its numbers of one year previously. By the end of its third year its ranks were reduced by as much as those of the 1923 brood were in its third and fourth years together.

If the third-year percentage is reckoned as having been eliminated at the age of 2½ years, the fourth at 3½, the fifth at 4½, and the remainder at 6½, the average age to which the 1923 brood survived works out at exactly four years, that of 1933 at less than three.

With regard to percentage reduction of brood strengths between the end of the first and that of the second year of life, the frequencies found for the two most prolific broods of the years in review, 1923 and 1928, show survivals of 90·1 and 92·7 % respectively. The average, in the case of the four abundant broods 1920, 1923, 1926, and 1928 (Raitt 1936, p. 21), is 81·3 %. Probable depletion of from 10 to 20 % is indicated. Taking 15 % as an estimated average, for every 1,000 haddock in the first year of life in the North Sea in 1923, 850 survived to the age of two and 723, 298, and 128 to three, four, and five years respectively. In the brood of 1933 the corresponding figures were 850, 298, 85, and 9, respectively.

Thompson, 1930, from the results of the Scottish age and frequency analyses of the North Sea haddock stock from 1919 to 1928, drew attention to indications of an increase in the rate of depletion of the 1926 brood as compared with that of 1923, and of the 1923 brood as compared with that of 1920. The data then available were not sufficiently extensive to allow him to go further. He also examined his statistics from region to region within the North Sea. He had already found three main areas of distinctive growth-rate, to the east (E), in the centre (C), and in the west (W) of the region (Thompson, 1929). The central area is that of slowest growth, the east fastest, and the west intermediate. The central area is that which is normally most densely populated

Table 3.

Frequencies Per 10 Hours' Fishing, North Sea Haddock Broods 1919—1936, Growth Areas E, C, and W, Second Year of Life.

Year Class	Frequency in Second Year			Percentage of Frequency in C		
	Area C	Area E	Area W	Area E	Area W	W+E
1919	1494	841	974	56	65	121
1920	4003	1006	2299	25	57	82
1921	226	75	60	33	27	60
1922	51	26	25	50	49	99
1923	4761	1932	2304	41	48	89
1924	1859	744	1263	40	68	108
1925	1460	929	537	64	37	101
1926	2106	1668	818	79	39	118
1927	401	318	200	79	50	129
1928	4962	1857	4748	37	96	133
1929	788	719	303	91	38	129
1930	407	155	439	38	108	146
1931	2205	1688	1712	77	78	155
1932	618	204	208	33	34	67
1933	766	947	237	124	31	155
1934	214	367	96	171	45	216
1935	2325	1768	2392	76	103	179
1936	371	204	164	55	44	99
			Mean:	65	57	122

by broods in their early years. In Table 3 are given the second-year frequencies of the broods of 1919 to 1936 in each of the three areas E, C, and W, together with their relative densities in E and W upon the basis of C reckoned as 100. The average for area W is 57, and for E is 65. Thompson found that the average rate of depletion in C was decidedly greater than in E, and decidedly greater in E than in W. His results are confirmed by subsequent data. Table 4 gives the percentages of the second-year frequencies surviving in each of the three growth areas for each brood from 1919 to 1935 in the third, fourth, fifth, sixth, and seventh years of life. In the figures for the separate areas, the same reduction of depletion in the earlier broods and the same severe increase in more recent years as demonstrated by the data for the North Sea as a whole can be recognised. In area W, however, the average percentages surviving were 90, 52, 24,

19, and 12, as against 83, 27, 12, 6, and 3 in area E, and 62, 20, 8, 2, and 1 in area C.

The main spawning grounds of North Sea haddock lie in the northern half of the region. The nursery grounds of young haddock are in the central section. Once maturity is reached migration to the northerly spawning grounds takes place each year at spawning time, followed, after spawning, by a return migration to the southerly feeding grounds. With advancing age, the more extended is the northerly movement and the less the southerly return (Thompson, 1929). First spawning is attained by a minority at the age of two, and by the majority at three (Raitt, 1932). From then on there is an annual gain in the numbers of age-groups to the north, north-west, and west of the region, that is area W, and a corresponding loss in the central section, that is area C. The low rate of depletion in W as compared with E and especially C is, as was recognised by Thompson, 1930, a reflection of that migrational loss and gain. It is seen in Table 4, particularly in those percentages which are over 100, that is of greater than second-year frequency.

the catch is returned to the sea, dead, as unsaleable. From investigations covering the seven years 1924 to 1931, Bowman, 1932, estimated that in the single statistical area C13, off Aberdeen, over 141½ million haddock, weighing approximately 16¾ thousand tons, were taken, and of these 51 % by number and 35 % by weight was rejected as too small for market purposes.

Commercial exploitation upon such a colossal scale cannot but have been a major factor in the severe increase in the mortality rate of the species in the area over the past twelve years.

Intensity of fishing is a function of numbers of boats, efficiencies of gears, and hours of operation. Fishing intensity in relation to species of demersal habitat in the North Sea is pre-eminently a function of the operations of British trawlers. Over the period 1926 to 1936, an average of 82 % per annum of the total European landings of demersal fish from the North Sea, as set out in the *Bulletin Statistique* for 1936, was secured by trawl. The landings of North Sea haddock in England and Scotland from 1920 to 1936 averaged 77 % of the total European catch (Table 5).

Table 4.

Percentages of Second Year Frequencies Surviving in Later Life, North Sea Haddock Broods 1919—1935, Areas E, C, and W.

Percentages of Second Year Frequencies surviving in Later Life.

Year Class	Area W. Age: 3	4	5	6	7	Area C. Age: 3	4	5	6	7	Area E. Age: 3	4	5	6	7
1919	71	30	14	4	6	70	26	7	3	·5	73	35	17	16	11
1920	63	35	23	13	3	76	41	11	3	1	100	51	31	9	8
1921	197	180	68	70	110	98	32	19	9	2	233	107	20	37	9
1922	84	72	64	120	20	47	21	25	4	4	231	65	46	8	8
1923	142	52	32	4	1	62	21	5	2	·3	78	28	10	1	1
1924	99	73	15	6	1	89	28	9	2	·3	106	18	7	1	·2
1925	105	55	18	8	2	61	18	9	1	·4	65	12	2	1	·2
1926	147	58	16	3	3	90	24	3	2	·3	93	9	4	1	·1
1927	68	55	16	17	2	93	25	12	2	·5	77	35	24	2	·1
1928	74	5	19	2	·3	60	20	5	2	·3	100	14	4	1	·3
1929	79	90	32	5	2	51	16	7	1	·2	35	15	3	1	·2
1930	102	26	4	2	1	38	15	2	1	0	80	15	3	1	0
1931	84	23	11	6	2	62	12	3	1	·5	22	5	1	0	·1
1932	80	36	23	8	—	34	8	3	0	—	70	10	0	·5	—
1933	43	20	6	—	—	47	8	3	—	—	16	3	1	—	—
1934	51	26	—	—	—	50	12	—	—	—	18	9	—	—	—
1935	52	—	—	—	—	32	—	—	—	—	17	—	—	—	—
Mean	90	52	24	19	12	62	20	8	2	1	83	27	12	6	3

Intensity of Fishing.

Over the period 1919 to 1936 the total European landings of North Sea haddock averaged approximately 126 million kilograms, or 126 thousand tons, per annum. Total landings do not represent total catch. The fishing gears of commerce capture the species before it is of marketable size. Part of

Data as to numbers of hours' fishing by all vessels landing catches in England and Scotland have been collected daily by the Ministry of Agriculture and Fisheries and the Fishery Board for Scotland from 1923 onwards. The resultant totals of hours' fishing per annum by all British steam trawlers operating in the North Sea are appended

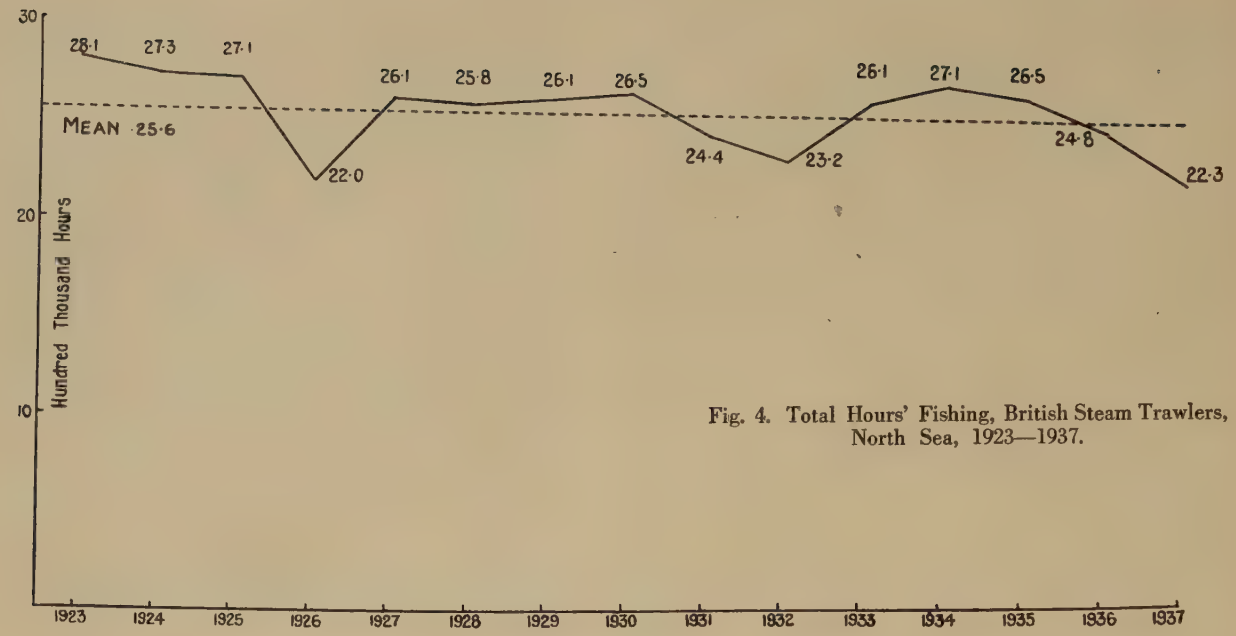

Fig. 4. Total Hours' Fishing, British Steam Trawlers, North Sea, 1923—1937.

to Table 5, and are graphed in Figure 4. They range from 2,807,647 in 1923 to 2,199,239 in 1926. They average 2,560,000. From the figures pertaining to the first half of the period some evidence might be deduced of a decline in fishing time from 1923 to 1926 and of a subsequent rise, such as would agree with the 1920 to 1930 survival rates of Figures 2 and 3. Thereafter, however, no increase in fishing time has taken place comparable with the severe decline in survival from 1926 to 1937. Over the entire period the figures are, in fact, remarkably constant.

It may be observed, in passing, that the percentage of the total European catch of haddock formed by English landings fell from over 50 to under 25 between 1922 and 1936, while that of

Table 5.

English, Scottish, and Total European Landings of North Sea Haddock, and Numbers of Hours' Fishing By British Steam Trawlers.

Calendar Year.	Landings of Haddock from North Sea. Thousand Kilos.			Percentage of Total.			Total Hours' Fishing by British Steam Trawlers.
	Total European.	England.	Scotland.	England.	Scotland.	England and Scotland.	
1919	204,012	78,684	36,715	38·6	18·0	56·6	—
1920	210,012	100,121	50,687	47·7	24·1	71·8	—
1921	171,291	83,194	42,334	48·6	24·7	73·3	—
1922	165,330	94,316	35,382	57·0	21·4	78·4	—
1923	124,129	68,141	30,331	54·9	24·4	79·3	2,807,647
1924	106,617	50,843	32,922	47·7	30·9	78·6	2,729,008
1925	147,083	77,830	40,804	52·9	27·7	80·6	2,705,503
1926	130,125	63,835	39,317	49·1	30·2	79.3	2,199,239
1927	125,223	54,303	42,099	43·4	33·6	77·0	2,611,967
1928	114,703	50,537	41,504	44·1	36·2	80·3	2,580,898
1929	107,744	47,313	39,964	43·9	37·1	81·0	2,607,996
1930	129,378	56,185	46,518	43·5	36·0	79·5	2,649,296
1931	109,893	39,103	45,598	35·6	41·5	77·1	2,435,422
1932	97,913	34,490	44,044	35·2	45·0	80·2	2,322,855
1933	108,032	39,815	48,185	36·9	44·6	81·5	2,607,583
1934	85,994	25,620	41,747	29·8	48·5	78·3	2,711,494
1935	67,328	17,070	35,430	25·4	52·6	78·0	2,651,631
1936	56,609	13,827	29,650	24·4	52·4	76·8	2,475,610
1937	—	—	—	—	— (Mean: 77·1)		2,231,222

Scotland rose from under 25 to over 50, the two together maintaining a steady level of from 77 to 82 (Table 5).

For information as to fishing intensity prior to 1923, resort must be made to the statistics of England and Scotland separately. In the Statistical Tables for the period, published by the Fishery Board for Scotland, there are no separate records of intensity of fishing operations in the North Sea. The figures include such voyages as were made by Scottish vessels to more distant grounds. Of the total Scottish catch of white fish from 1921 to 1927, however, an average of 85 % per annum came from home waters, and, from 1919 to 1937, an average of 72 % per annum was secured by trawl (Table 6). It is of further assistance to note that of the total Scottish catch of white fish by trawler from 1919 to 1937 an average of 71 % per annum was landed at the single port, Aberdeen. Total Scottish statistics may be taken as applying almost exclusively to North Sea operations, and Aberdeen figures may be regarded as a useful guide to Scottish activities as a whole where comprehensive figures are not available.

Table 6.

Scottish White Fish Landings, Number of Trawlers, and Duration of Trip.

Year	Landings of White Fish in Scotland. Percentage of Total Catch taken in North Sea.	Percentage of Total Catch taken by Trawl.	Percentage of Total Trawl Catch landed at Aberdeen.	Total Number of Scottish Trawlers in Operation.	Average Days' Duration of Trip (Aberdeen Trawlers)
1919	—	66	75	294	5·1
1920	—	75	87	383	5·5
1921	92	67	74	418	5·2
1922	87	64	71	383	5·5
1923	85	63	61	336	5·2
1924	85	71	71	329	5·6
1925	89	72	68	341	4·9
1926	84	70	71	313	4·5
1927	84	72	69	319	4·5
1928	88	73	69	314	4·5
1929	87	74	68	329	4·7
1930	86	73	70	341	4·6
1931	84	75	72	338	4·7
1932	82	75	72	335	4·7
1933	84	76	73	327	4·3
1934	86	73	75	344	4·4
1935	85	77	78	373	4·6
1936	80	75	78	383	5·1
1937	84	73	74	346	4·6
Mean	85	72	71	(1913 : 320)	

Table 6 includes details of the total numbers of trawlers operating from Scottish ports from 1919 to 1937 as against the figure for 1913. Immediately following the cessation of the hostilities of 1914—1918, the Scottish trawling industry, according to numbers of vessels employed, was assumed practically at 1913 level and by 1921 had increased by almost 50 %. A decline subsequently took place. Around 1926—1928 the number of vessels had fallen to the 1913 level. Thereafter a slight increase was maintained to about 1934. In 1935—36 the numbers tended to approach the 1920—22 level but fell away again considerably in 1937. Similarly, the average number of days' duration of trip by vessels operating from Aberdeen (Table 6) ranged from 5·1 to 5·6 between 1919 and 1924, fell to 4·5 in 1926—27, fluctuated from 4·7 to 4·3 until 1936 when 5·1 was reached again, and fell once more to 4·5 in 1937. Intensity of fishing certainly appears to have been greater between 1920 and 1922 and to have fallen away, just as evidenced by the increase in survival percentages in Table 2 and Figures 2 and 3, over the period 1920 to 1926. Since then, just as with total numbers of hours' fishing, no increase in operations is indicated such as would explain the severe reduction in survival rate from 1926 to 1937.

Statistics as to numbers of English trawlers cannot be read in the same way. The trawling fleets of England exploit Icelandic, Faroe, and Barents Sea grounds far more than those of Scotland. The total numbers of landings from the North Sea by English trawlers from 1919 onwards are, however, available in the Statistical Tables of the Ministry of Agriculture and Fisheries (Figure 5). The period 1920—1922 again shows the greatest activity on record.

Regarding efficiency of gear employed, two important changes took place in the period in review. The first was the introduction of the Vigneron-Dahl gear which made its initial appearance in 1923 and later entirely replaced the Otter Trawl in the North Sea fishery. From about 1926 onwards, that is the period when severe and continued reduction in survival took place, the V.D. gear was that in general use. Its efficiency over that of the ordinary Otter Trawl was investigated by Bowman, 1932. In 862 hours' trawling by research vessel using the V.D. trawl, and 528 using the Otter Trawl, 387,515 and 167,208 haddock were caught, equivalent to catches of 4,495 and 3,167 per ten hours' fishing respectively. The catch by V.D. gear was 1·42 times greater than that of the Otter Trawl. No significant difference was found in the selective action of the two gears. With the general adoption of the V.D. trawl an increase of practically 50 % in intensity of fishing was thus brought about, as a result of which severe reduction in stock survival is quite understandable.

The second change in gear employed was, however, in the opposite direction. In 1933 the British Government introduced legislation stipulating an increase in the size of the mesh of net then in use to a minimum of 21—24 rounds per yard, the equivalent of a mesh measurement of about 3 inches

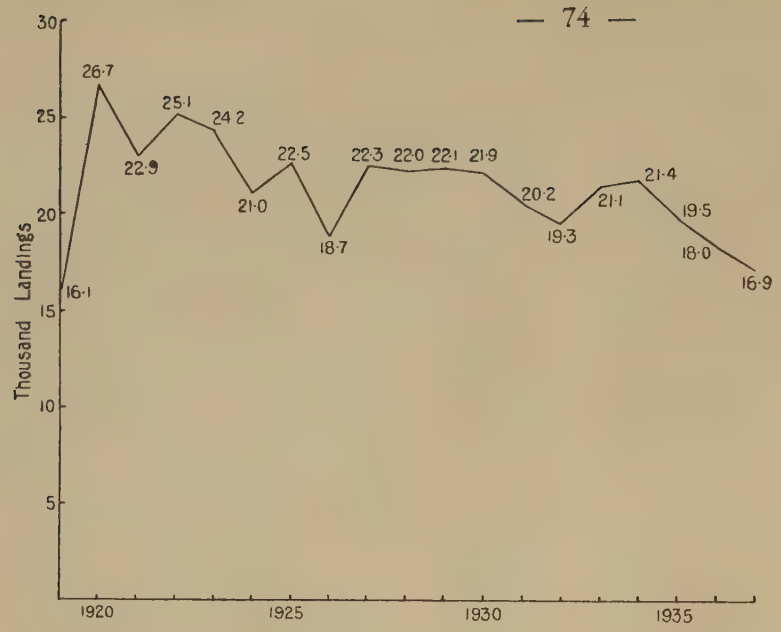

Fig. 5. Total Numbers of Landings from North Sea by English Steam Trawlers.

from knot to knot drawn taut. According to D a v i s, 1934, a trawl which conforms to the 1933 regulations may begin to retain haddock when they are no more than 14 cm. in length and escape from it is impossible for all individuals of 32 cm. and over. A trawl of smaller mesh such as was previously in use began to take toll of the stock at an even earlier point, and escape from it became impossible for individuals correspondingly less in length. The increase in mesh had as its aim the saving of the younger fish of the stock. There is no sign whatever in the extensive data here submitted of any resultant reduction in rate of depletion. It is, in fact, in the latest years of the period reviewed and in the survival from the second to the third year that the greatest increase in depletion has taken place.

There is, however, another way in which increase in depletion may be brought about, that is by increase in growth-rate and the earlier capture by commercial fishing gears resultant therefrom.

Rate of Growth.

From the routine trawling operations of the "Explorer", information is amassed as to sizes as well as numbers of haddock of different ages at different times and different locations. In his growth-rate investigations, T h o m p s o n, 1929, calculated the average length of each age-group in each trawl haul taken. He combined the figures obtained according to month of year and to the statistical squares to which they belonged, weighting

Table 7.

Lengths Attained by North Sea Haddock Broods 1925 to 1937.

Year Class.	Lengths attained at the end of Different Years of Life in Haddock of the North Sea.											
	First			Second			Third			Fourth.		
	E	W	C	E	W	C	E	W	C	E	W	C
1925	—	—	—	—	25·1	22·7	32·8	28·8	27·9	31·4	32·8	31·7
1926	—	16·7	15·8	25·9	24·8	23·3	29·9	31·0	27·5	30·6	33·5	29·9
1927	14·5	15·8	14·9	24·0	24·1	23·4	27·6	30·7	27·8	33·2	33·8	31·1
1928	16·6	16·8	16·7	22·1	23·9	22·2	28·6	28·6	26·4	35·3	32·3	30·5
1929	15·9	16·8	16·1	25·2	24·1	22·9	31·5	29·5	28·0	39·0	32·2	31·1
1930	16·1	17·1	17·1	26·4	25·2	24·5	35·2	30·1	29·4	32·0	35·6	34·7
1931	18·3	17·5	17·2	26·6	25·0	24·5	29·3	29·8	29·7	34·6	36·0	33·4
1932	19·4	17·0	17·5	25·8	25·1	24·8	31·9	30·5	30·3	—	35·9	33·8
1933	17·3	17·6	17·0	25·9	27·0	26·0	—	32·6	31·6	—	37·4	35·6
1934	17·1	18·0	18·0	—	27·4	26·9	—	34·0	32·7	—	40·0	35·9
1935	—	17·8	17·6	—	26·1	24·6	—	31·8	29·1	—	—	—
1936	—	17·0	16·8	—	25·4	24·5	—	—	—	—	—	—
1937	—	17·6	18·1	—	—	—	—	—	—	—	—	—

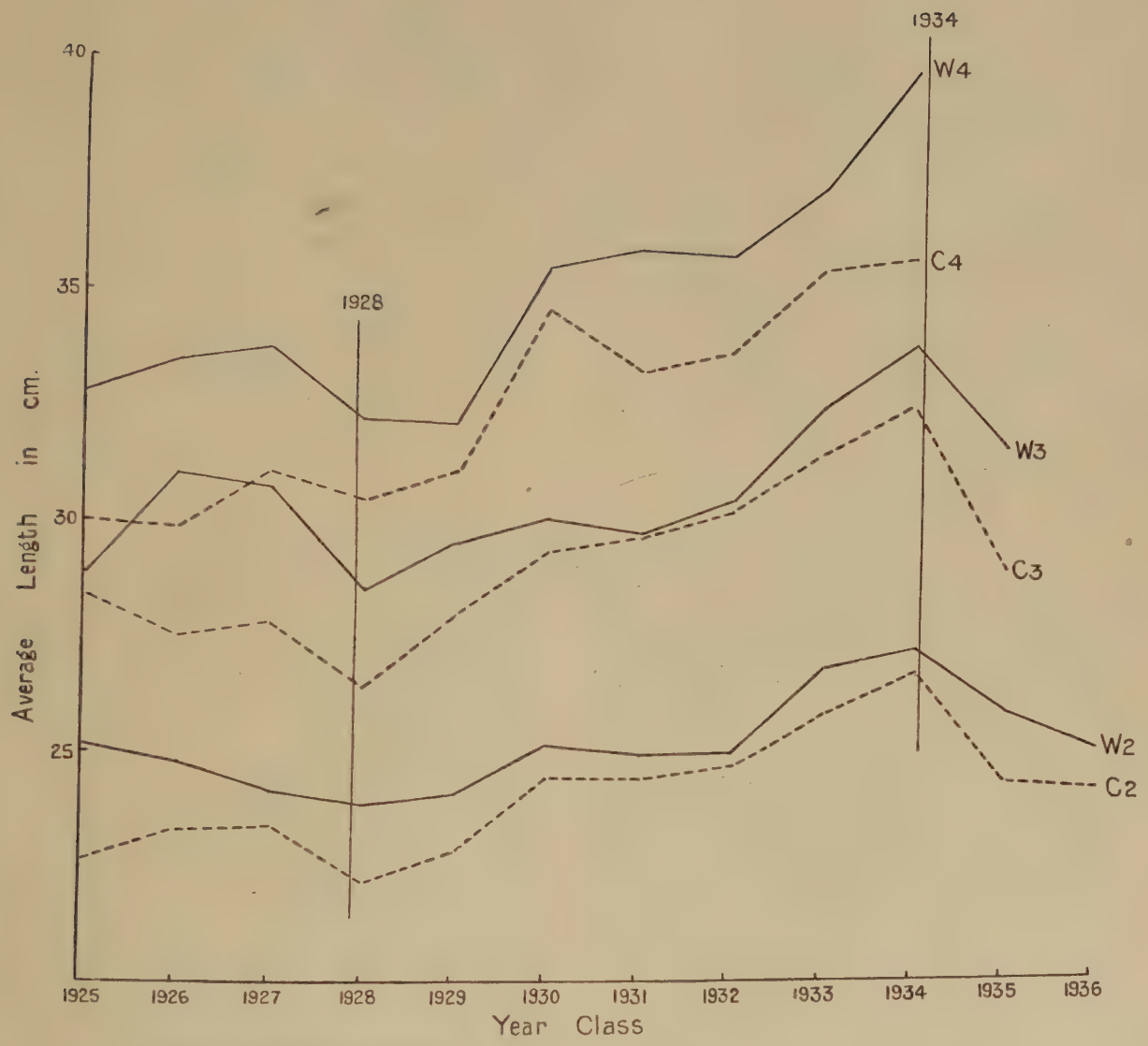

Fig. 6. North Sea Haddock Growth-Rates, Broods 1925—1936, Areas C and W, 2nd, 3rd and 4th Years.

each according to the number of fish to which it referred. He then grouped like square with like and finally arrived at division of the North Sea into regions of distinctive growth and at the average lengths typical of their respective stocks. The three main growth-rate areas he established, E, C, and W, have already been referred to.

Upon the same basis as Thompson, the writer has calculated the average lengths of North Sea haddock broods from 1925 onwards at different ages in each of the three areas, E, C, and W. The material used includes all trawl hauls taken by the "Explorer" from year to year in the months November to May. June to October is the feeding and growing season. From November to May, growth is practically at a standstill. Length measurements taken from November to May give the averages attained at the end of successive years of life.

Table 7, which incorporates length measurements and age determinations of 220,000 fish, gives the averages attained by year-classes 1925 to 1937 at the end of their first, second, third and fourth years. The figures relating to areas C and W and to years two, three, and four are graphed in Figure 6.

Contrary to statements to the effect that haddock

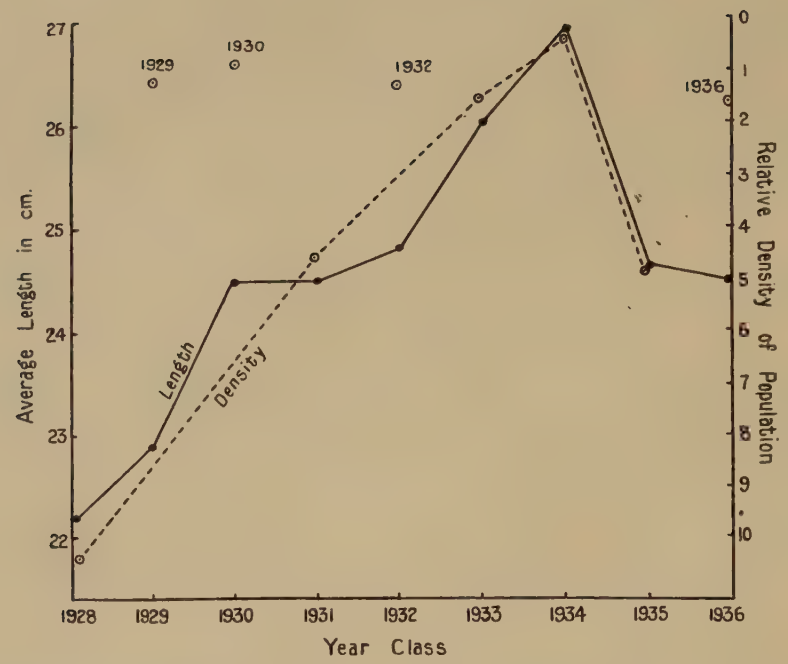

Fig. 7.
Average Length and Relative Frequency, Second Year, Area C, North Sea Haddock Broods, 1928—1936.

growth-rates do not vary appreciably from year to year, very considerable differences have been found. In the case of the 1928 brood in area W at the end of its fourth year, for example, the average obtained was 32·3 cm. as against 40·0 cm. in the brood of 1934, a difference of 7·7 cm., or practically 25 %. Similarly wide variations occur in years one, two, and three, in both C and W, and also E. The most striking character of the data, however, is the steady advance in average length from the 1928 year-class to that of 1934, those very broods in which severe increase in rate of depletion took place. The average lengths of the 1928 year-class at the end of successive years of life, as compared with the brood of 1934, were:—

	1st		2nd		3rd		4th	
	C	W	C	W	C	W	C	W
	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
1928	16·7	16·8	22·2	23·9	26·4	28·6	30·5	32·3
1934	18·0	18·0	26·9	27·4	32·7	34·0	35·9	40·0

According to Davis (1934), at a length of about 23 cm. 75 haddock escape for every 25 retained by a trawl of regulation mesh, at about 26 cm. 50 escape for every 50 retained, and at about 28 cm. 25 escape for every 75 retained. In the case of the 1928 brood in area C at the end of the third year of life, the average length attained coincides with the length at which there is 50 % retention. With the 1934 brood the average length is the point beyond which there is 100 % retention. Such increase in growth-rate, coupled with the introduction of gear of such effectiveness as the V.D. cannot but have produced increased depletion from 1926—1928 onwards. Increase in length would indeed appear to have counteracted the saving effect of the enlargement of mesh of the regulations of 1933.

Figures 7 and 8 give the graphs of the average lengths of the broods of from 1928 onwards at the end of their second year in areas C and W, together with their respective abundances as given in Table 3. In the case of the broods of 1928, 1931, 1933, 1934, and 1935, the two sets of points practically coincide. Degree of growth and density of population in these five broods are practically proportional in inverse relationship. The only possible conclusion is that growth-rate varies in accordance with amount of competition for available food.

The rates of growth of the broods of 1929, 1930, 1932, and 1936, however, disagree with their respective densities. In each case they are far too low. That fact lends support to, and does not weaken, the contention that growth is a function of brood fluctuations. Once they have taken to bottom habitat, North Sea haddock remain more or less where they are for the first two years of life. They do not take part in any major migration until the advent of first maturity. One-year-old and two-year-old fish occupy the self-same grounds. The poor brood of 1936 in its first year was in competition for food with the prolific brood of 1935 in its second year. That it should suffer reduction in growth-rate thereby, out of proportion to its own density, is only to be expected, and similarly with the brood of 1932 in relation to the

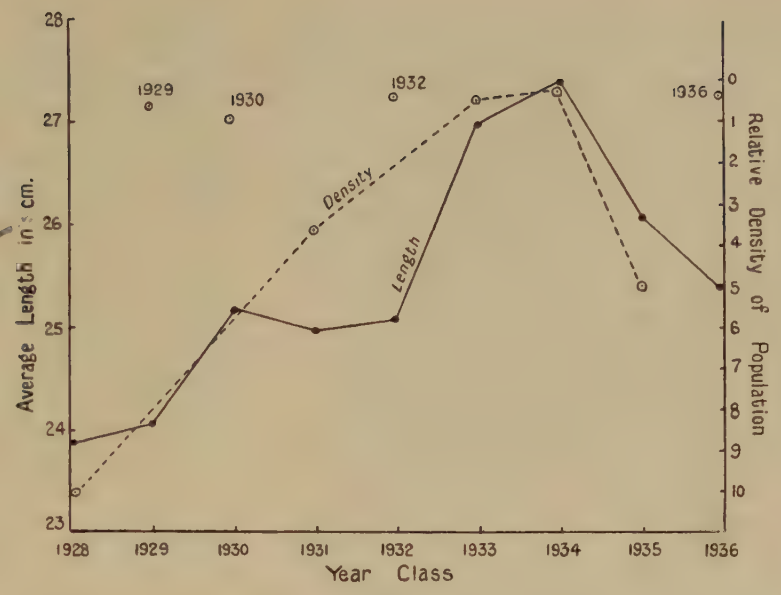

Fig. 8.
Average Length and Relative Frequency, Second Year, Area W, North Sea Haddock Broods, 1928—1936.

outstanding brood of 1931, and the brood of 1929 in relation to that of 1928. So enormously abundant was the brood of 1928 that both 1929 and 1930 would appear to have been adversely affected thereby.

Reliable estimates of first-year frequencies in the different areas are lacking. Length measurements for area E are incomplete. What is shown for areas C and W in the second year, however, cannot but apply elsewhere.

Growth-rate varies in accordance with density of population, and the steady increase in average length in the North Sea broods of 1928 to 1934 is a function of the replenishment fluctuations of the region, a reflection of the increase in the frequency of occurrence of poor broods in recent years.

Such was the sequence of brood strengths in the years immediately preceding 1928 that the effect upon growth is complex and does not lend itself to simple analyses. If density affects growth in any brood, however, it must surely affect all.

If brood density affects growth, it follows that severe increase in rate of depletion will have the same tendency. The poorer the brood the faster is its growth, and the faster the growth the quicker it is fished out, and the quicker it is fished out the faster the growth of the upcoming stock.

It also follows that both unsuccessful brood survival and increased depletion are to a certain extent counteracted by increase in weight.

The fecundity of the species and the advent of first maturity have likewise been shown to be functions of growth (Raitt, 1932). The fishing out of two-thirds of a year-class by the end of its third year of life is forcing the brunt of stock replenishment upon fish of poor reproductive capacity and upon year-classes all individuals of which have not reached maturity. A North Sea haddock of average length produces, at two years of age, about 30,000 eggs. Between the ages of two and three fecundity is, on the average, increased about three times, between two and four about five times, between two and five about seven times, and between two and six about nine times. The question arises as to whether the increase in the frequency of poor broods in recent years is not at any rate partially brought about by the increase in depletion and consequent reduction of the potential fertility of the stock as a whole. Increase in growth-rate, of course, will to some extent counteract depletion in both the percentage reaching maturity at an early age and the number of eggs produced.

Summary and Conclusions.

In the course of investigations extending over 20 years, and involving age and frequency data concerning over half a million haddock of the self-contained and self-supporting North Sea stock, wide variations have been found both in the initial strengths of broods and in the rate of their subsequent depletion.

From 1919 to 1936, there occurred in the North Sea six broods of outstanding abundance, seven of outstandingly inferior numerical order, and six of intermediate proportions. The degree of fluctuation was of the order of over 60 to 1 (the 1928 and 1922 broods respectively). The latter half of the period was marked by an increase in the frequency of occurrence of less successful broods and by a decrease in average annual recruitment.

The rate of mortality of the broods was found to have decreased between the fishing years 1920—

1922 and 1925—1927, but to have increased severely from then onwards. Of the second-year frequency of the brood of 1923, for instance, 15 % was removed in the third year, a further 50 in the fourth, and 20 in the fifth. Of the second-year frequency of the brood of 1933, 65 % was removed in the third, a further 25 in the fourth, and nine in the fifth, leaving only one per cent. as against 15 in the case of the brood of 1923. By the end of its third year the ranks of the 1933 brood were reduced by two-thirds of their second-year strength, which was as much as the 1923 brood suffered in its third and fourth years together. The average age to which the 1923 brood survived was four, and that of the 1933 brood less than three.

Between 1920 and 1925 a temporary reduction in fishing effort appears to have taken place, such as would explain the decrease in rate of depletion over these years. No increase in fishing time has since occurred in any way comparable with the severe increase in depletion which then set in. About 1926, however, the V.D. gear generally replaced the ordinary Otter Trawl. It has been shown to have an efficiency over the latter of 1·42 to 1. Such increased catching power might well have brought about the severe decrease in stock survival.

The British regulations of 1933 stipulating the use of a minimum size of mesh of net were introduced in an effort to reduce the destruction of stock taking place. According to the present data they have not done so. The growth-rate of the haddock is shown to have increased considerably over the same period. The average length of the brood of 1934 was 25 % greater than that of the 1928 year-class. Such increased growth means earlier entry into the fishing gears of commerce and, consequently, increased rate of depletion. Increase in rate of growth appears to have temporarily masked the effect of the 1933 regulations, but for which the decline in stocks would have been even more severe.

The present data show close agreement between these variations in growth-rate and the degree of brood density, the poorer the brood the less the competition for available food and the faster the rate of growth. It follows that increased depletion will itself have had a similar tendency, the poorer the brood the faster its growth, the faster the growth the quicker its depletion, and the quicker the depletion the less competition for the upcoming stock and the greater its growth.

The fishing out of two-thirds of a year-class by the end of its third year of life is forcing the brunt of stock replenishment upon fish of poor reproductive capacity and upon year-classes all individuals of which have not reached maturity, and the question arises as to whether the increase in the frequency of occurrence of poor broods in recent years has not been at any rate partially brought about thereby.

Increase in growth-rate must, of course, have to a certain extent counteracted increased depletion, in weight of landings, and in both the percentage of a year-class reaching maturity at an early age and the numbers of eggs produced.

Once the density of a stock is on the decline through removal per annum of greater average numbers than are being added on the average by spawning, the process would seem to be one which gathers momentum like a falling stone. Reduction of numbers means less competition for food, which means greater growth-rate, which means earlier fishing out, all of which indicates reduction of potential fertility, which in return would mean still further reduction in numbers and so on. On the other hand once decrease in rate of depletion were established greater survival would mean more competition for food, less growth-rate, later entry into the trawl, greater survival to spawning age, larger broods and so on.

The present evidence indicates that the current rate of depletion of the North Sea haddock stock is of the former order.

The matter may also be viewed from the standpoint of yield in relation to fishing effort. The average lengths in broods of about the 1933 growth-level may be taken, in round figures, as 30, 35, 40, and 45 cm. at the end of the third, fourth, fifth, and sixth years of life respectively, and in broods of about the 1923 level as 25, 30, 35 and 40 cm. respectively. The 1923 brood was similar in density and growth to that of 1928. The weights corresponding to these lengths are 136, 238, 388, 586, and 843 gm. respectively (Raitt, 1932). Taking the whole of the percentages surviving after the fifth year as eliminated in the sixth, and calculating from these weights data the yield in each year of life in the 1923 type of brood as compared with the 1933 type, upon the basis of the present depletion figures, the following totals are obtained:—

1923	%		Wt.	
Third Year	15	× 136 =	2,040	
Fourth Year	50	× 238 =	11,900	
Fifth Year	20	× 388 =	7,760	
Sixth Year	15	× 586 =	8,790	
				30,490 g.

1933	%		Wt.	
Third Year	65	× 238 =	15,470	
Fourth Year	25	× 388 =	9,700	
Fifth Year	9	× 586 =	5,274	
Sixth Year	1	× 843 =	843	
				31,287 g.

In other words, the vastly increased growth-rate is balanced by the vastly increased depletion. The lesser fishing intensity yields practically the same as the greater. The thesis of Graham, 1938, that high fishing intensity is uneconomical, reduction

of effort, and costs, resulting in no less yield, is fully supported.

From the point of view of increasing average length of life and number of time spawning, from the point of view of checking decline in total stock, and from the point of view of equal yield at less expense, the advisability of a reduction in fishing intensity by a return to the 1923 level would seem to be unquestionable.

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7.

ON THE DEPLETION OF THE NORTH SEA HADDOCK FISHERY.

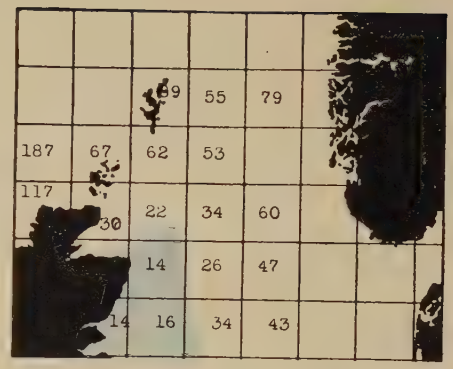
BY

D'ARCY W. THOMPSON.

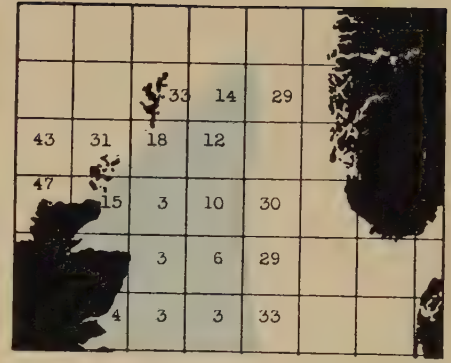
Large

Medium

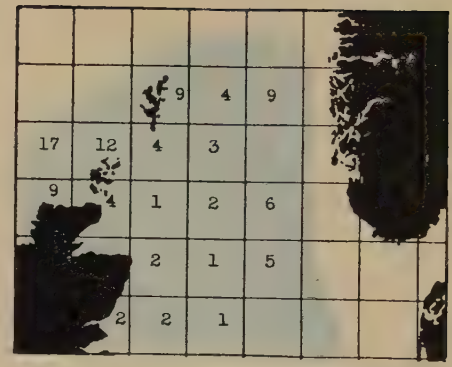
Small



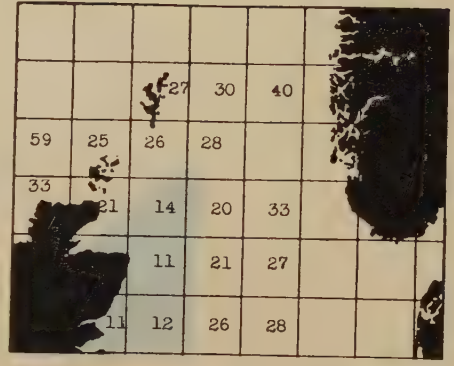
Faroe: 90 Iceland: 39



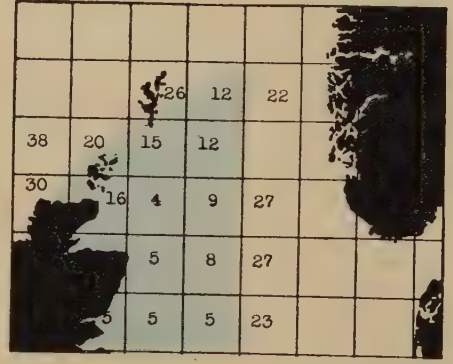
Faroe: 33 Iceland: 61



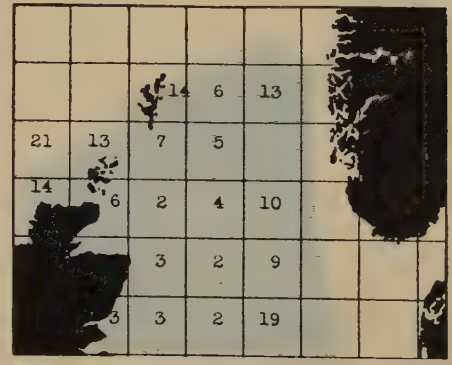
Faroe: 13 Iceland: 40



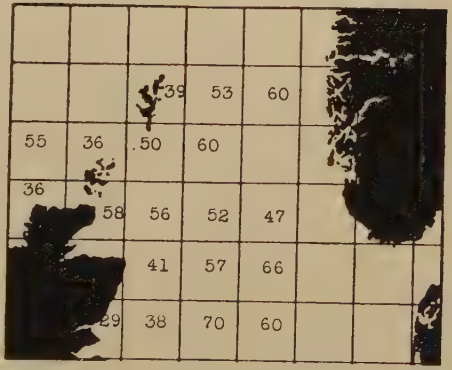
Faroe: 15 Iceland: 2



Faroe: 11 Iceland: 16

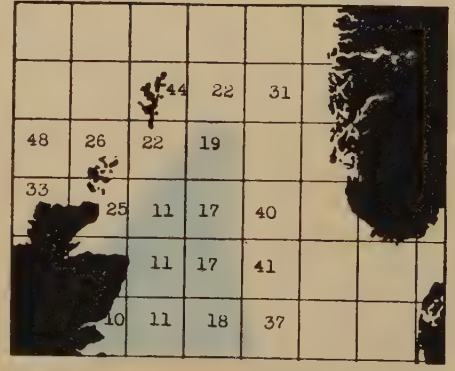


Faroe: 12 Iceland: 15



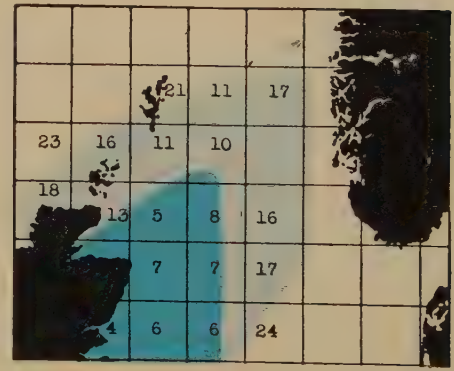
Faroe: 15 Iceland: 33

1901—1910



Faroe: 11 Iceland: 31

1921—1930



Faroe: 13 Iceland: 10

1931—1937

Mean Annual Catch of Haddock, in cwt. per 100 hours' fishing. Aberdeen Trawlers.

THE Aberdeen Market Statistics are well known to all students of the Fisheries. They have been kept in their present form for nearly forty years, since 1901, and were the first attempt to correlate the average catch of fish with the place of capture and the time spent on fishing. As in all other commercial statistics the data are somewhat rough, but they are compiled faithfully, and their value continually increases as time goes on.

I offer here a very brief epitome of the Haddock-statistics. The mean annual catch, per hundred hours' trawling, is set forth for nineteen areas of the North Sea, together with Iceland and Faroe: these being the areas where trawling has been most extensive and continuous. The results have been grouped in three periods, viz., 1901—1910, 1921—30, and 1931—1937; the decade 1911—1920, when fishing was greatly interrupted and the records very imperfect, has been left out of account. The net result is a series of three charts each, for each class of Haddock, Large, Medium and Small; and a comparison of these charts, for the three periods, is very striking indeed. For many or most of us, the "depletion of the North Sea" was for years a matter of argument, or of opinion; the present statistics and the charts which illustrate them shew it to be a fact beyond doubt or question.

To sum up, our first chart, of Large Haddock, shews that from 1901 to 1910, the areas off the Scottish east coast yielded from 14 to 30 cwt. per 100 hours, rising to 60 or even to 90 cwt. in the Shetland area, and to still higher figures in the north-west. During the 1921—30 decade, the catch had dropped to less than 20 cwt. over the greater part of the map, and to three or four cwt. off the east coast. In our last period, 1931—1937, no single area (save Iceland) yielded as much as 20 cwt., and in fully half it had dropped to one, or two, or three cwt. As to the Medium Haddock, the first chart shows a small patch off the east coast where the mean catch is under 20 cwt. per 100 hours; but in our last period the region yielding less than 20 cwt. extends all over the map, save for one distant area (with 21 cwt.) near Rona and Sule Skerry. The figures for Small Haddock are not less striking and lamentable. The first decade shews no area with less than 20 cwt., and only one under 30 cwt.; the last period shows eight areas with 10 cwt. or less, and only three with more than 20 cwt.

To complete the story, it is necessary to deal with the class of Extra Small, sometimes called the "Chat" Haddocks; these are the fish of round about (say) 24 cm. long, and mostly in the second year of their age. But these cannot be treated in the same fashion as the other groups, because, in the earlier years which we are considering, they were of no account in the market and were not even brought ashore. They were not recognised as a Class till about 1905, and only after the war did they begin to assume commercial importance. Of recent years the quantities landed, actual and relative, of these Extra Small fish have increased enormously, and they now constitute from 80 to 90 per cent. of the whole catch of Haddocks, and at least about 70 per cent. of the value of the same. We have no data to shew conclusively whether these small fish are more or less abundant on the fishing grounds than in former years; we only know that the quantities landed have increased enormously. We do not see, so far as I can judge, any sign of their diminution; and they are thus in striking contrast to all the other classes of Haddock, even to that of "Smalls", immediately above them.

It would seem that, while trawling takes so formidable a toll of the stock that fewer and fewer haddock grow up to adult age, and that even the young fish (of three years old or thereby) are become conspicuously few, yet on the other hand the rate of multiplication, the production of eggs and larvae, is so bountiful that the youngest fish are still plentiful on the fishing grounds, but cease to be so long before the breeding-age. The moral would seem to be plain enough, that a self-denying ordinance closing a large area of sea would in a very few years do a vast deal to promote recovery.

8.

ON THE LAWS OF DECREASE IN FISH STOCKS.

BY

AAGE J. C. JENSEN

A new year-class of fish does not enter the fishery until its individuals have reached a certain length (viz., the minimum size for species subject to legal size-regulations, or the size retained by the mesh used,) or, finally, when the fish reach a certain stage, such as first maturity. Conditions determining the resulting recruitment of catchable individuals are manifold, as stocks subject to fishery may be recruited from highly different growth-areas.

It is more simple to determine the decrease of a year-class from the date when new recruits can no longer be expected to join the fishable stock. From then on depletion is limited mainly to two causes, natural mortality and fishing, a third cause, emigration, also may affect the decrease within a narrow field of observation, the single fishing ground or area. In this part of the life-cycle the depletion due to the fishing is leastly influenced by other factors, and this phase therefore is of a special interest to the overfishing question as well as the question of the optimum catch, so urgently emphasized recently by E. S. Russell, Johan Hjort, M. Graham, Ad. Bückmann and others.

Professor Hjort specially stresses the illustration of "the changes in the average mortality within the population in correlation with variations in the intensity or effectivity of the fishing operation within the area of distribution of the population under observation". In this connexion "mortality" means "total decrease of the stock, in some cases including the effect of emigration" (12).

Such a decrease frequently follows a "Sigmoid Curve", and Ottestad has made an interesting experiment to show that the annual decrease in catches of the 1904 year-class of Norwegian spring-herring closely follows "the exponential frequency function" (15).

The law most frequently introduced into investigations of the decrease of a stock is, however, "Malthus's Geometric Series". Thompson and Bell (24) have employed this law on catches of halibut with great success. This and other laws have been discussed thoroughly by Bückmann (5) and Graham (9).

As regards *the condition for the geometrical ratio of the decrease*, a few remarks may be made before reviewing various stocks as examples. Assuming all age-groups subject to an even fishery as well as to even percentage mortality from natural causes, the same percentage decrease may be expected from year to year.

As a general rule one would expect a high mortality at the youngest stages, decreasing gradually until a fairly even mortality during growth to adults, and as adults, as well as during the first maturity years have been reached, thereafter with increasing age an increasing mortality from natural causes is to be expected. (There are well-known exceptions, such as *Oncorhynchus*, which shows a mortality of nearly 100 % during or after spawning). The rate of natural mortality in fish stocks is not well known, although deductions have been possible from marking experiments and quantitative stock investigations, but to the best of my knowledge, experience does not so far indicate any particular change in death-rate round spawning ages of our food-fish, nor, on the other hand, does the present results preclude any such change.

Fisheries are everywhere of so high an intensity that few food-fish reach an age at which the natural cause of death would be old age. One exception, however, might exist in a part of the Norwegian spring-herring stock, which is so slowly reduced that even 20-year-old specimens are not at all rare in catches.

As to decrease of stock by the fishery, line-fishing is non-selective among age-groups (in similar biological groups) old enough to take the bait. Also the trawl may be considered non-selective if fish small enough to escape through the mesh are neglected. — M. Graham draws attention to a very important fact (8), namely, that "trawlers aim at, and on the average succeed in, finding particular small patches of maximum concentration of fish"; accordingly such catches may contain individuals at first maturity-stage in relatively high numbers, such stages being more likely to shoal than those slightly younger. Another fact also should be remembered, that the normal decrease may be disturbed by a sudden arrival of new recruits immigrating in numbers (see below, under cod stocks in Greenland and the Faroes).

These points should be remembered when studying the following survey of decreases in year-classes in various areas for the purpose of answering the question, "Do decreases follow, approximately, any definite law?".

Methods of Investigation.

In order to see whether the decrease follows a geometric series or proceeds by even annual percentages, the *logarithmic curve* seems the most

practical way of demonstration, as this must be a straight line where the geometric law is followed, (cf. B r a d y, 1927 (3)). The curvature — or the bend of the curve formed by plotting actual values or decreases — does not clearly suggest either a geometric series or make evident the rapidity of decrease; the logarithmic line or curve, on the other hand, immediately shows the approach to the law, as well as the rapidity of decrease, by the gradient. Moreover, sudden changes in rate of decrease are immediately detectable by change of gradient.

Decreases may be considered in two ways, as decrease of the year-class or as decrease in stock, the former was used by O t t e s t a d (loc. cit.) in connexion with the Norwegian spring-herring, the latter by the present author in some of the following examples. When considering year-classes, it may be advisable to smooth the material over several succeeding year-classes to avoid sampling errors and to obtain a general rule or formula indicating the annual toll by a fishery of constant intensity year by year throughout the life-cycle of the year-class or year-classes investigated. Changing fishing intensity, however, would cause deviations that would make the formula useless, though without lessening the interest of following a certain year-class from age-group to age-group to study the effect of the changing fishery.

The greatest practical question is the effect on the stock of a certain fishery carried out over a longer or shorter period of years; such investigations supply data for comparison of the average decrease within the population under a certain fishery condition with the average decrease under another intensity or effectivity of the fishery in some other years or with the average decrease in another population (cf. H j o r t, loc. cit.). This will be obtained by considering the way in which *any year-class* would change quantitatively from age-group to age-group under the conditions given. This method will be explained below under the heading, Stock of Cod, Transition Area, where it has been used to study the stock of the Belt cod. Again, it may be useful to consider means of a series of years to avoid sampling errors, etc.

When decreases change from year to year, quantitative determinations of stocks will always be necessary, percentage-observations only being insufficient.

The North Atlantic Cod Stock.

Transition Area.

Figure 1 illustrates the cod stocks of the Transition Area as determined by quantitative hauls from research vessels of the Danish Biological Station. For the years down to 1929 the figures given by E. M. P o u l s e n (16) have been used.

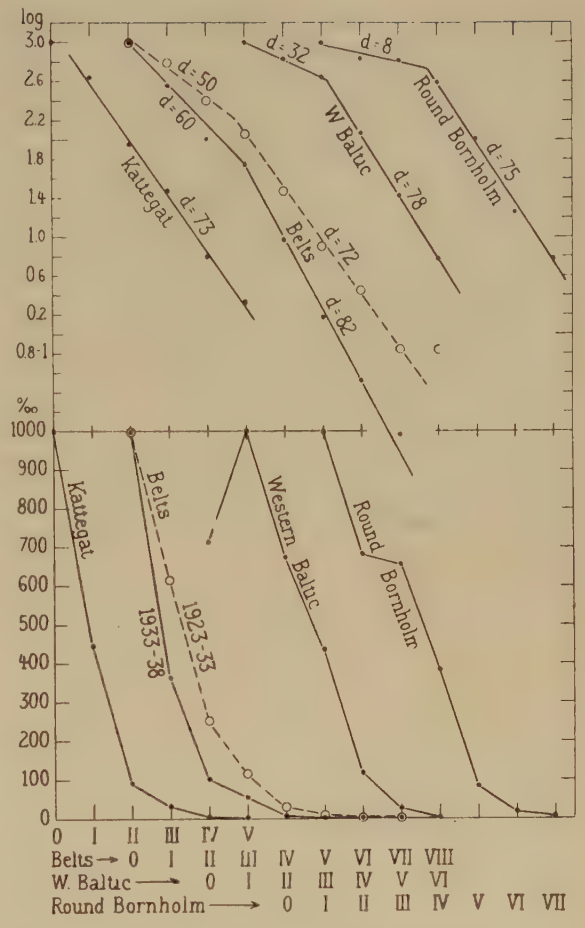


Fig. 1. The stock of cod in the Transition Area (see text).

These stock-curves show little tendency to follow, even approximately, a sigmoid curve. The quantitative fishery seems to catch all age-groups equally well, the 0-group most numerously, the other groups in gradually less numbers of quantities.

The logarithmic curves of Fig. 1 for different areas all show a similar tendency towards equal percentage decreases year by year of certain year-classes. In the Kattegat the decreases are fairly similar whether in regard to the year-classes 1924—28 or to those of 1929—33, and the graph therefore records an average decrease of all year-classes, viz., 1924—33. For the Belts the period discussed shows increasing rapidity in decrease of year-classes. Figure 1 illustrates the decreases during 1923—33 and 1933—38 respectively, calculated as follows:— The average decrease of a given year-class has been employed to determine the residual stock, year by year, of 1000 fish of the 0-group, assuming that conditions determining the decrease (fishery, natural mortality, emigration etc.)

during the year in question continue throughout the life-cycle of the year-class. In other words, the mean number of the 0-group individuals in each of the years 1933—37, and the mean of I-group individuals in each of the years 1934—38, determine the mean percentage decrease from Group 0 to Group I; similarly the mean of I-Gr. individuals in 1933—37 and that of II-Gr. individuals in 1934—38, give the percentage decrease from Group I to II, and so on. With the values thus determined, an average stock for the period under discussion has been estimated in numbers per mille within each age-group. This rather simple method has been preferred to that employed by Graham (10).

Although fishing intensity has grown year by year, causing a single year-class to be subjected to a steadily increasing rate of removal, developments have been so smooth that year-classes also show an even annual percentage decrease from the III-group onwards, accelerating from year-class to year-class, thus:—

Year-classes	From 0- to III Gr.	From III-Gr. onwards.
1919—23	53 %	73 %
1924—28	50 %	76 %
1929—33	46 %	82 %

In Figure 1 moreover is shown the reduction of the year-classes 1927—32 in the Western Baltic and of the year-classes 1930—34 at Bornholm.

Within each area the turning point from slow decrease to rapid decrease occurs about the time when maturity is reached, the reason probably being that, by then, shoaling at the spawning season allows the fishermen to remove greater numbers of fish. Difference in growth may also have some effect. At Bornholm, the coastal waters are little fished for small cod; growth is slow and the fish therefore enter the fishery at a higher age than elsewhere. In the Kattegat, where growth is rapid, the turn from slow to rapid decrease seems to occur shortly before the fish reach the III-group. The heavier decrease of Belt stocks observed is due to increased intensity of fishing. In the Belt Sea the decrease of younger age-groups remained fairly steady until 1932; if anything, decreases were going down (53 %—46 %, but since then it has been rising to 60 %). During the last 5 years the demand from the filleting factories for small cod has been growing, and the reduction of the stock younger than the III-group has therefore grown heavier.

There seems to exist a characteristic difference between the areal decreases of younger age-groups, in as much as the decrease seems to be less, going from the Kattegat to the Baltic. An explanation may be that these groups migrate towards the Baltic. Racial investigations support this, as the number of rays in the 2nd dorsal fin increases from age-group to age-group (E. M. Poulsen, (16), who, however, did not consider a single year-class in his paper; the increasing D_2 may be due to fluctuations in year-classes). From 1919 to 1933 the inflow from the Kattegat to the Belt Sea increased considerably (13), which may have occasioned a downward direction in the decrease of year-classes during these years.

North-Sea.

Graham's statement that trawlers search for small patches of maximum concentration of fish (8) must be borne in mind when studying the age-composition of English trawler catches according to Graham (10). It will be seen that in the mean of the year-classes 1929—30—31 (Fig. 2, curves NS.) "the apparent mortality is less from V- to VI-group" than for younger age-groups. Graham's explanation is that the III-group, and certainly the IV- and V-groups, are less well represented than they should be relative to the VI-group, and that the chief cause of this is probably the lack of concentration of fish before they are mature (8).

Figure 2 shows a percentage decrease from groups II to V of about 66 %, while the decrease from V- to VII-group is about 42 % a year. In view of the explanation given by Graham, cited above, it is doubtful whether we can expect the same percentage-decrease from one age-group to the next to be a normal feature in these figures for the age-composition of the trawler catches from the V- to the VII-group.

Lofoten.

Figure 2 (curves L) shows the decrease after the age of 10 of cod in a stock caught by long-line in the years 1932—35, calculated from Rollefsen's investigations. The catch per man per day of the various age-groups has been calculated from the frequencies per thousand and from the total catch per man per day. The decrease of the stock under conditions prevailing from 1932—35 has then been calculated in a way similar to that employed for the Belts, the maximum value of an odd year-class here found by the X-Gr. has been put equal to 1000. It will be noted that the logarithmic line from the age of 12 to 19 is almost a straight line; the deviations are irregularly disposed on either side of the line and may therefore be considered to be caused by sampling errors or other occasional errors. The general trend shows an even percentage decrease year by year.

Iceland.

A similar calculation has been employed for the years 1932—36 to construct the curves Va in Figure 2, from the catch per 100 hooks as calculated from the percentage composition of catches, recorded by A. Fridriksson and Å. Vedel Tåning (20) and A. Fridriksson (6), and

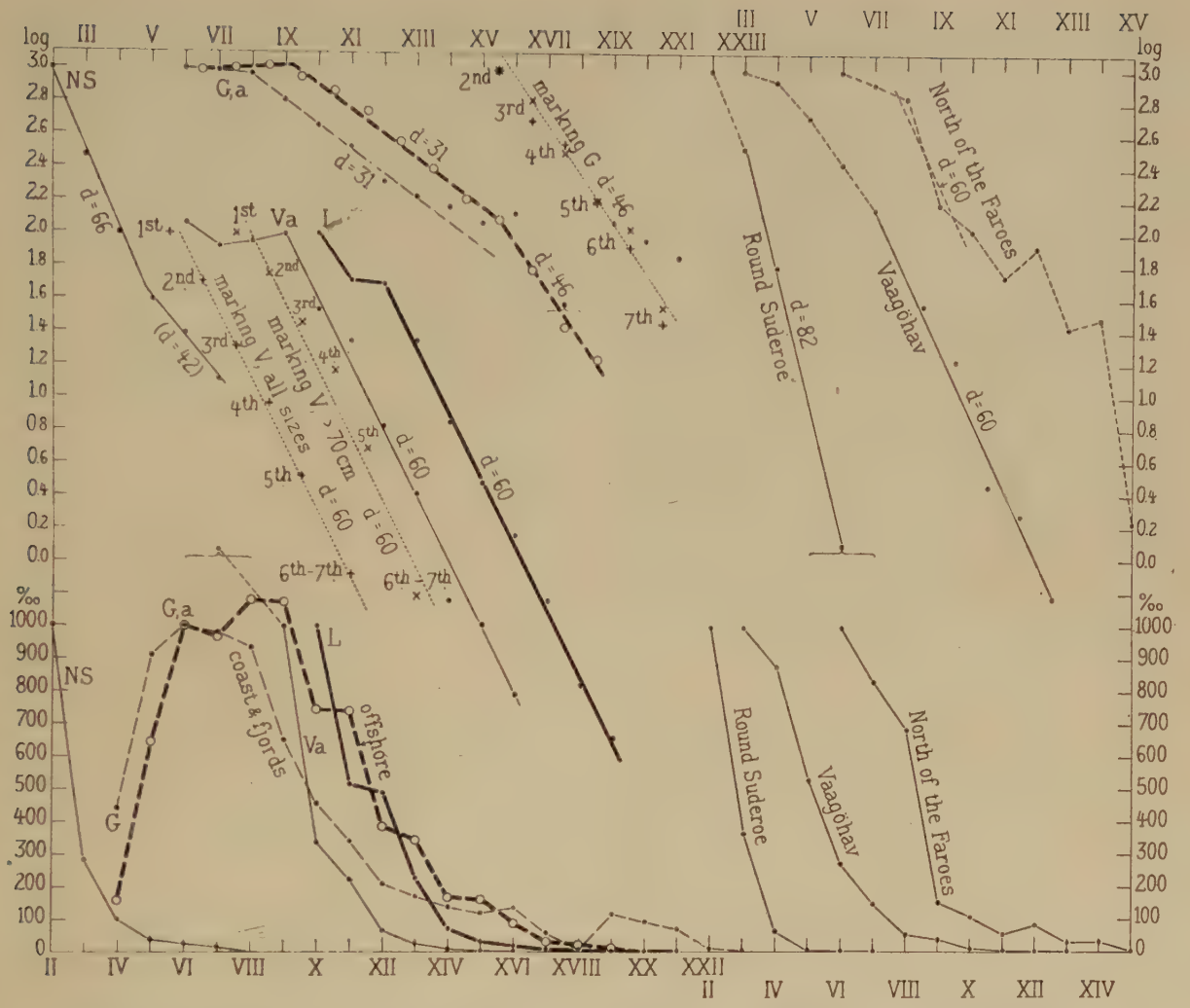


Fig. 2. The stocks of cod in the North Sea (NS), Lofoten (L), South-West Iceland (Va and V), West Greenland (G, a and G) and at the Faroes (see text). Logarithms of values from Lofoten and Iceland are displaced for drawing facilities.

from the total catch per 100 hooks published by Fridriksson (6).

The very complicated recruitment in this area is the cause of the irregular decrease of the age-groups VI to IX. Decrease and recruitment of stocks in these waters have been studied in detail by Fridriksson. The Iceland curves in Figure 2 seem to indicate that it is justifiable in this area also to reckon with an even percentage decrease (of about 60 %) from the age of 10 years onwards. Yet migrations and exchanges with other stocks (proved by Dr. Tåning's marking experiments) are bound to cause deviations from a smooth percentage decrease.

The figure also gives the logarithms of recaptures of marked fish (22), partly for all markings, partly for mature cod only (> 70 cm.), "1st, 2nd" year etc. not referring to age-groups of the abscissal-axis. It will be observed that the decreases of all sizes show perfectly even percentage decreases, like the analyses of stocks, while the decrease calculated in respect of mature cod is very uneven, a fact probably due either to biological conditions, or to sampling error.

West Greenland.

The reduction of the cod stock in West Greenland during 1930—38 is shown in Figure 2, curves G, a and G produced from data kindly supplied by Paul M. Hansen. For this area no records exist of catch per fishing unit, and the decrease has therefore been calculated from percentage

composition of catches by hook and long-line by the method used for the Belt records.

Through the logarithms of the age-groups in fjords and coastal waters a straight line representing a percentage decrease of 31 % has been drawn (curves G, a). The deviations from the XIV-group onwards, however, are undoubtedly systematic. Paul M. Hansen has very kindly informed me that migrations play an important rôle in this area, and that different stocks must be separately considered by districts; a discussion of these questions is in course of preparation.

The thick broken curve in Figure 2 illustrates a corresponding number of age-groups caught on offshore banks, with logarithms plotted for 2-year smoothed values, showing a definite, smooth percentage decrease of some 31 % per annum from the age of 9 to 15, and of some 45 % per annum from the age of 16 onwards. Further, logarithms of recaptures (up to 7 years after marking) from marking experiments by Tåning (22) are given. The fish marked were of very different ages, and the values were plotted without considering the scale of abscissae. Markings were made partly in coastal waters and fjords, partly on the banks. The recapture record shows the same smooth percentage decrease of 45 % from year to year.

Faroes.

In Figure 2 the reduction is shown of the cod stocks of various districts based on percentage composition of hand-line and long-line catches, 1933—38, the data (together with other valuable information) having been kindly placed at my disposal by Dr. Tåning. The decrease of the stock varies considerably between the districts, the main causes being very different fisheries, migrations within the areas before and after spawning, and possibly also some immigration of cod of about 9 years of age or more from the Faroe-Iceland ridge and even Iceland. This immigration is most characteristic north of the islands, where the logarithms show systematic deviations from the smooth percentage decrease. A relatively heavy immigration of cod of the age-groups X, XI, XII and XIII cause the apparent annual decrease after the age-group IX to be very low. Such admixture seems to be much less marked in the Vaagöhav, where a smooth percentage decrease of 60 % is indicated. It is remarkable that the annual decrease from about Group VII to IX within the northern area is more or less similar to that of Vaagöhavet. For the district round the Suderö the annual reduction of the stock is very great, owing to the simultaneous effect of intense fishing and emigration from this young fish district.

Summary of the Conditions of Cod Reductions.

From the above discussion of the cod stocks, or the stock subject to fishery, it appears that reductions can hardly be expressed mathematically by a sigmoid curve calculated from the exponential frequency distribution, whilst the reductions in all areas show a definite tendency — in some cases very marked towards an even percentage decrease year by year. Migrations from one area to another play an important rôle in some districts. The heaviest decrease (70—80 %) occurs within the Transition area, due almost exclusively to the fishery, as emigrations are rare. A similar great reduction is recorded at Suderö (Faroes), but here the decrease is partly due to emigration. It is remarkable that decreases in Lofoten, S.W.-Iceland and Vaagöhavet in the Faroes are all as heavy as 60 %, while on the West Greenland banks the annual toll recorded is 45 %. The coastal decrease in Greenland must remain undetermined until these stocks have been thoroughly investigated.

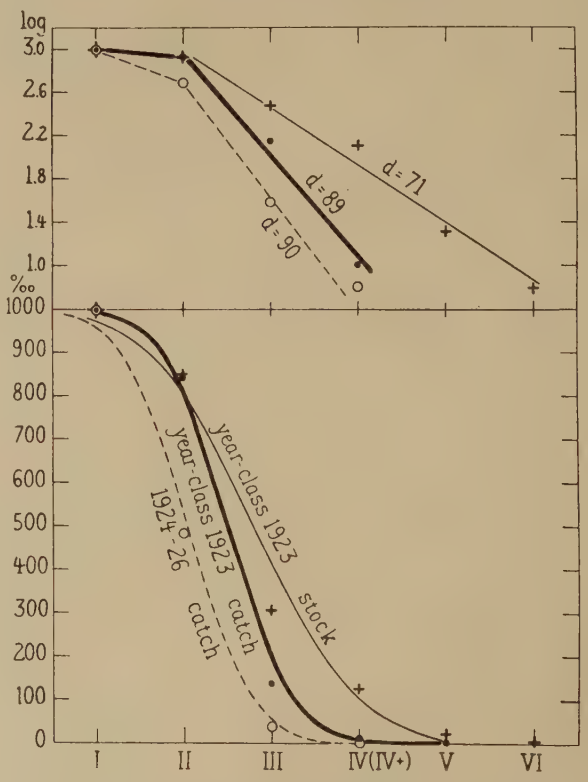


Fig. 3. The reduction of certain year-classes of haddock in the North Sea (from Scottish investigations).

Haddock in the North Sea.

Regarding the North Sea haddock, so well investigated by Bowman, Thompson and Raitt, it will be seen from Figure 3 that quantities of certain year-classes, especially the rich 1923 year-class, follow the Ottestad sigmoid curve fairly well. The figure shows decreases calculated from quantitative material collected by

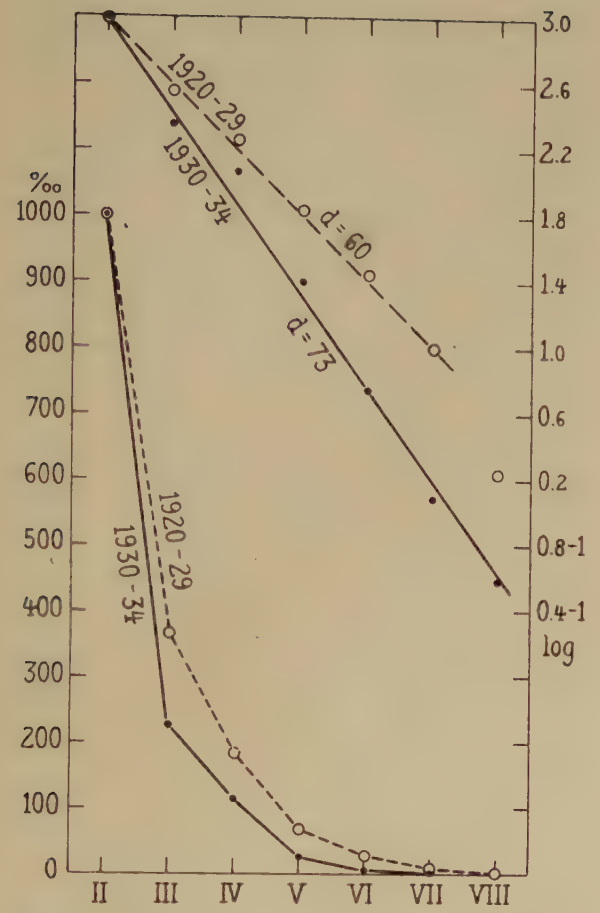


Fig. 4. The average reduction of the stock of haddock under the fishing intensity of 1920—29 and 1930—34 (see text).

research vessels [Raitt (17)] and from trawler-catches [Bowman (2)] respectively. It is noteworthy that the latter, commercial records show more rapid reductions than the former, possibly owing to the fact that data have been collected from characteristically different areas, or perhaps because the commercial fishery attacks concentrated shoals causing more rapid decreases of these than of more scattered stocks in other areas.

Finally Figure 3 shows the reduction of the year-classes 1924—26, according to Bowman's records (2) of Scottish trawler catches. The logarithmic curves for the catch are plotted on the assumption that the age-groups IV and IV+ decrease by a percentage similar to the II- and III-groups, i.e., 83 % for the 1923-class, 92 % for the 1924—26 classes. The decrease of the stock has also been expressed by the Ottestad sigmoid curve, and it is an open question whether the comparatively rapid decrease of older age-groups indicated by the sigmoid curve or the smooth percentage decrease at this age comes nearest to the actual conditions.

It is a well-known fact that the fishing intensity for haddock has greatly increased during the years after the war. Figure 4 shows the reductions after the II-Gr. during 1920—29, and 1930—34, calculated from Raitt's figures (17). In both periods the percentage decrease was smooth, about 60 % in the former, about 73 % in the latter.

Raitt in this volume gives a very crucial investigation into the reduction of the stock compared with the changes in the fishing intensity and in the growth rate of the haddock.

According to Raitt's contribution it is obvious that the series of years should have been divided somewhat differently from that employed in Fig. 4, in order to give the best view of the changes in the reduction. In the table below, therefore, the percentage reduction has been shown from one age-group to the next one during the various epochs of different fishing intensity: 1) 1919—24, before the introduction of the V. D. trawl, 2) 1928—33 immediately after the introduction of this gear, and 3) 1933—37 during recent years.

The annual percentage reduction of the stock of haddock, during periods of different fishing intensity (calculated from figures given by Raitt in this volume):

	1919—24	1928-33	1933—37
I/II	21·3	32·7	68·5
II/III	57·9	77·7	75·0
III/IV	54·8	49·5	68·2
IV/V	48·1	77·2	66·0
V/VI	76·7	68·2	71·5
VI/VII	37·8	79·5	64·7
VII/VIII	86·6	70·5	57·2
VIII/IX	40·0	79·2	46·7
Average per year between			
II- and VII-gr.	55·1	72·4	69·1
II- and IX-gr.	57·4	73·1	64·2

It seems quite justified to assume a smooth percentage decrease year by year from the II-group to the VII-group, and perhaps also in the yet older age-groups. The deviation from this rule may be due essentially to sampling errors.

Stock of Plaice.

Stock of Plaice in the Belts.

Figure 5 shows the catch of plaice of the year-classes 1927—33 in quantitative experimental hauls undertaken by the Danish Biological Station, from Samsø through the Great Belt to Smaalandshavet.

The local stock and the transplanted stocks were distinguished (H. Blegvad (1), 1934) by means of otolith studies. The decrease from the III- to IV-group is 80 %, and from the numbers of older age-groups found it seems most likely that there is the same percentage decrease year by year. The stock is very thin (amounting to 0·85 local plaice

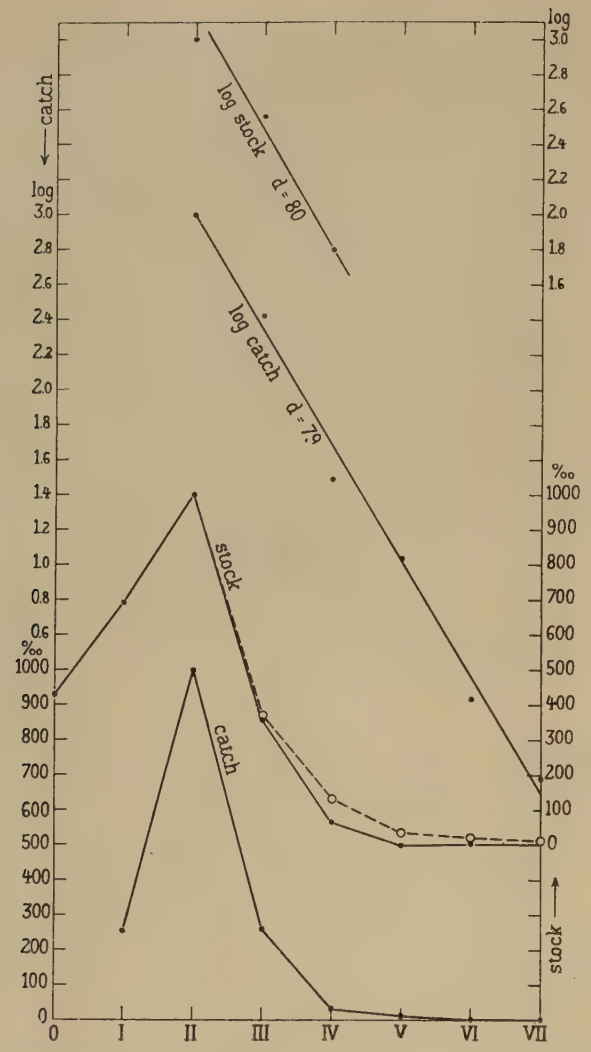


Fig. 5. The plaice in the Belts. The broken line indicates the total stock, including the transplanted plaice.

of the IV-group per 5 hours fishing), and sampling errors may accordingly be rather large. It is fortunate therefore that the question of the obedience of the decrease of the stock to law may be settled from other data.

For these waters, a large number of age analyses are available, relating to commercial catches of plaice from August 1931—February 1939, summarized in Figure 5. The logarithmic curve of quantities clearly indicates that is is justifiable to accept a percentage decrease of 80 % per annum for the stock from the II-group. Marking experiments indicate a much higher rate of decrease, namely 90—95 % per annum (H. Blegvad, loc. cit., Table 11, p. 9), a percentage that is undoubtedly too high and must be due to a great number of marked fish having been liberated on much frequented fishing grounds and caught soon after liberation.

Stock of Plaice in the North Sea.

Figure 6 shows the decrease of certain year-classes of the Leman-Haaks plaice according to quantitative investigations by D. E. Thursby-Pelham (25). In this case the Ottestad sigmoid curves have been calculated and recorded. The logarithms of the numbers of fish within the various age-groups here also seem to prove that a smooth (or even) percentage decrease from the V-group stage. The straight lines drawn from Group III are imaginary only; the decrease was considerably less for the rich year-classes 1920—21—22 than for the poor ones 1923—24 (an augmented reduction rate for the poor year-classes seems to be a general rule). As regards later years the reduction of the stock is based on English marking experiments, 1929—32, for which logarithms were plotted from values published by C. F. Hickling (11), who has also used the logarithms to demonstrate the smooth percentage reduction. The logarithms of recaptures in the several years have been plotted without considering the age of the fish — generally 2, 3 and 4 years old when marked. It appears from the figure that the annual decrease in recent years has been about 70 %.

For Helgoland Bay, Bückmann, has studied the question of percentage decrease of the stock thoroughly, by means of quantitative fishing experiments (4). The mean annual reduction from the V- to the VI-group has been calculated to be 76 %, from the VI- to the VII-group 83 %. The average reduction during the fishery of 1929—33 has been shown in Figure 6, curve "stock".

U. Schmidt (19) supplies some age-determinations, of catches of the german cutter-fishery also used in constructing Figure 6, which show the decrease of the stock by the fishery of the year-classes 1925—29 (marked "German Bight, catch"). The logarithms of quantities of the several age-groups indicate an even percentage decrease from groups VII to IX (about 80 %). For this area also English marking experiments are available (C. F. Hickling, loc. cit.) and from which logarithms of the recaptures have been plotted, showing an annual decrease from 1 to 3 years after marking (at Norderney, Schiermonnikoog, Borkum Reef and Terschelling, 1929—32) of some 66 %, during the older age-groups 79 % per annum. The markings at Helgoland in 1931—32 also exhibit a 79 % decrease per annum.

At Horns Rev (Fig. 6) the amount of plaice of the year-classes 1933—34 have been determined from group I to V from quantitative fishing experiments by Kommissionen for Danmarks Fiskeri- og Havundersøgelser. The "Ottestad-curve" has been drawn and it will be seen that these year-classes do

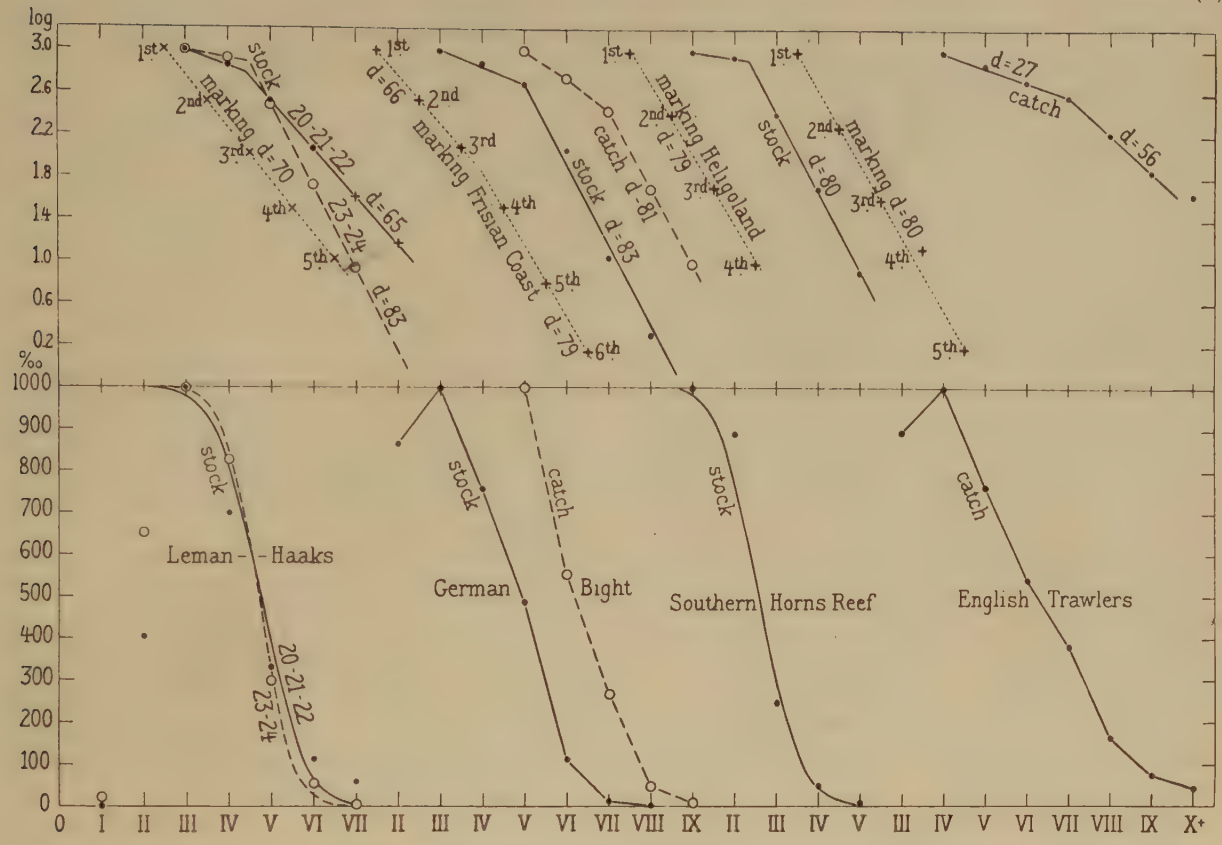


Fig. 6. The stock of plaice in the North Sea (see text).

not follow the curve; the logarithms of quantities of the several age-groups, however, indicate that the percentage decrease is constant from year to year at about 80 % per annum from groups III to V. Further, the corresponding logarithms (according to Hickling) of recaptures from marking experiments 1929—32 indicate a smooth decrease of about 80 %.

It is characteristic that so high a percentage begins as early as the III-group, due undoubtedly to the intense trawling of recent years. It has been possible to prove that the reduction of the stock of these young age-groups during 1925—27, when trawling was not nearly so intense, was a few per cent. only (14).

All North Sea areas so far discussed have been nursery grounds from where the plaice emigrate after reaching a length of about 27 cm.

Finally, Fig. 6 shows the age-composition computed from English trawl catches (D. E. Thursby-Pelham (25)). From this an even percentage decrease is observable from the VII-group onwards, but it is considerably below that of the nursery grounds. The slow reduction from groups IV to VII must be ascribed to the heavy immigration of these age-groups from the nursery grounds. At the VII-group stage the recruitment is completed (practically), although some recruitment probably goes on from the West Frisian nursery grounds, where older plaice are rather scarce. The reduction computed must be considered the approximate actual decrease in the area from the Southern Bight to South of the Dogger, the area chiefly visited by English trawlers. On the Doggerbank the reduction must be more rapid, as Danish marking experiments record recaptures of 75 % during the 12 months following liberation (21).

Plaice stock in Faxa Bay, Iceland.

Dr. Tåning has kindly made available data from the Faxa Bay area (20), where quantitative hauls were made during 1924—27, and 1931—34, while nonquantitative hauls only exist for the years 1928 and 1929.

The decrease of the stocks from the two former periods, territorially as well as extra-territorially, is demonstrated in Figure 7 (this material is being thoroughly discussed in the reports of the Faxa Bay Committee). The territorial data does not

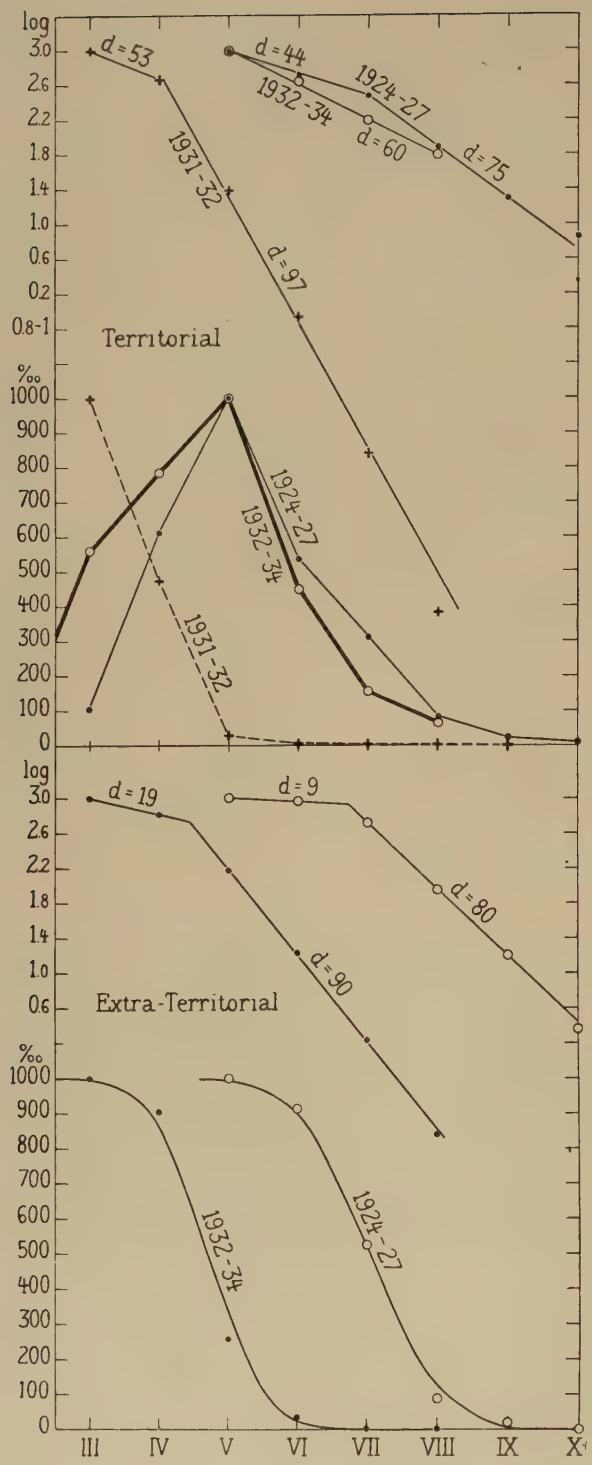


Fig. 7. The stock of plaice in Faxa Bay.

show any approach to Ottestad's sigmoid curve, while this stock shows a smooth percentage decrease, thus:

Age-groups:	III-IV, IV-V,	V-VI, VI-VII,	VII-VIII, VIII-IX
1924—27:	increase	44 %	75 %
1928—29[1]):	increase	52 %	66 %
1931—32:	53 %	97 %	
1932—34:	increase	60 %	

[1]) Calculated from percentage age-analyses, and thus less reliable.

The annual decrease territorially was extraordinarily high from 1931 to 1932, when (according to Tåning) the fishery was very intense, but otherwise the reduction was fairly constant during the 11 years, although with a marked tendency towards an age composition of younger year-classes.

Extra-territorially the decrease is fairly close to a sigmoid curve but at the same time shows smooth percentage reduction from year to year in the older age-groups.

The periods 1924—27 and 1931—34 are compared in the figure and in both cases a very heavy decrease is observable, as high as 90 % (in 1932—34) for the V+ groups. Moreover, the heavy reduction for the latter period begins as early as the IV—V-groups, while in the case of the former it does not commence until the VI—VII-groups.

Southern North Sea Herring.

Percentage compositions of catches of Downs Herring are available for a long period, from Hodgson for the Lowestoft-Yarmouth area, and from le Gall for the Southern North Sea and the Eastern Channel (7).

The average composition of the stocks is shown in Figure 8. The logarithms of the numbers of the several age-groups, when plotted, do not lie on a straight line, and the stock does not decrease by even percentages from year to year. If the percentage decrease from one age-group to that following be plotted, it will be seen that the actual percentage decrease, from group VI, increases linearly. The explanation may be either an increase in natural mortality and emigration with increasing age or that the width of mesh is adjusted to select size-categories that give the most economical yield, i.e., the younger age-groups which normally are the most abundant. An adjustment of mesh to select those sizes must result in a steadily growing fraction of the stock being left uncaught with increasing age. This argument would explain a numerically even increase of the percentage by which the number of each age-group seems to be reduced, but a closer investigation is of most importance and greatly to be desired.

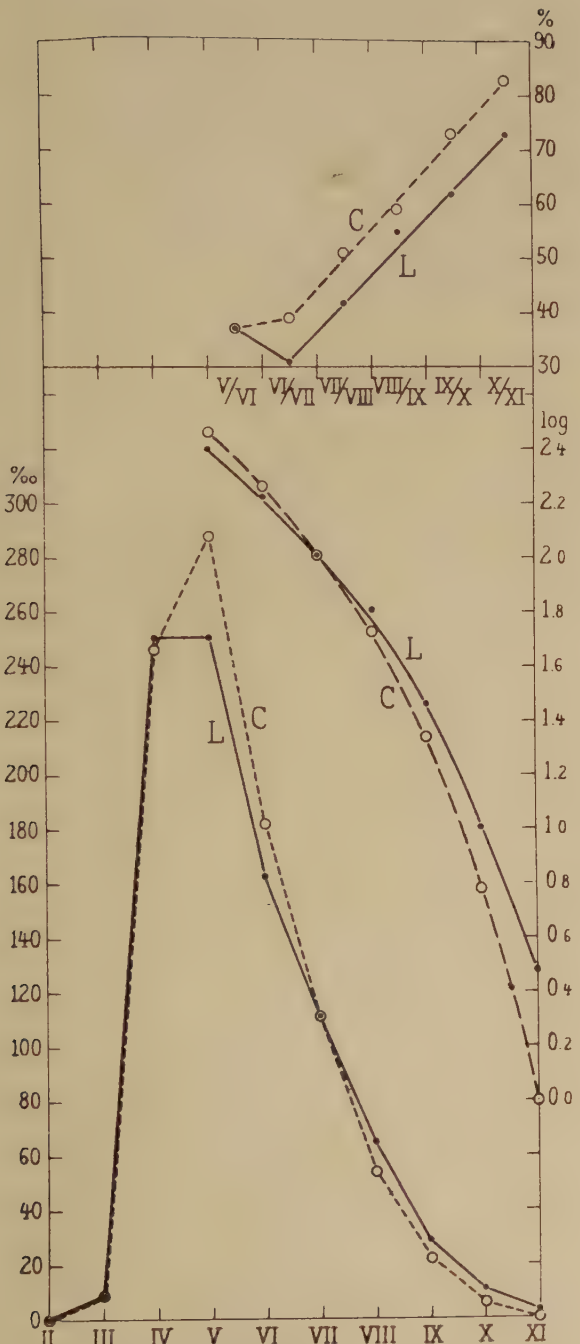


Fig. 8. The average age-composition of the catch of herring in the Southern North Sea and Eastern Channel. I: Lowestoft-Yarmouth 1923—34 (acc. to Hodgson), C: Eastern Channel and Southern North Sea, 1924—34 (acc. to le Gall). Uppermost curves indicate the percentage reduction from one age-group to the next one.

On the importance of determining the formula for decreases of stocks.

The stock of bottom species within a specified area subject to scientific hauls and/or commercial fisheries may in many cases be considered as being subject to reductions from year to year by even annual percentages, provided the fishing intensity is permanent; deviations from this rule would be due to sampling errors.

This being so, forecasts of future stocks under similar fishing conditions would be simplified, as also would be the calculation of stocks under different fishing intensities.

The investigation of systematic deviations from the smooth percentage decrease should extend the possibility of obtaining information on emigration, immigration, and other changes in the biology of the species at certain ages.

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9.

DER EINFLUSS DER FISCHEREI AUF DEN SCHOLLEN- UND FLUNDERBESTAND IN DER OSTSEE.

VON

ERICH FISCHER,
BERLIN.

DIE Einwirkung einer intensiven Fischerei auf den Bestand zeigt sich deutlich an dem Schollen- und Flunderbestand der Ostsee. Besonders auffällig ist der Einfluss bei der Scholle, welche in der Ostsee ohnehin unter ungünstigen ökologischen Verhältnissen lebt, da sie höheren Salzgehalt und Wärme liebt. Aber auch bei der Flunder, die besonders in der mittleren Ostsee optimale Lebensbedingungen findet, hat sich in den letzten Jahren gezeigt, dass der Bestand durch die ausserordentlich gesteigerte Fischerei merklich angegriffen wird.

I.

Die Ostsee ist ein relativ kleines Meer, das bei geringer Ausdehnung in die Breite eine sehr erhebliche Längenausdehnung hat. Daraus ergibt sich eine ausserordentlich langgestreckte Küste, von der aus seit uralten Zeiten in allen Ländern eine lebhafte Fischerei in der See betrieben worden ist. — Fischereilich betrachtet liegen die natürlichen Verhältnisse in der Ostsee wenig günstig. Der geringe Salzgehalt bedingt — im Gegensatz zur Nordsee — schon eine Armut an Nutzfischarten. Dazu hindert die allmähliche Aussüssung des Wassers nach Osten hin und, umgekehrt, die Zunahme des Salzgehaltes nach Westen das Vorkommen einzelner Arten in allen Gebieten der Ostsee. Das geht bekanntlich so weit, dass im Osten und Norden ein fast gänzlich anders zusammengesetzter Nutzfischbestand vorhanden ist als im Westen.

Trotz dieser ungünstigen Verhältnisse hat sich in der Ostsee eine starke Fischerei entwickelt, an der sich zur Zeit neun Anliegerstaaten beteiligen. So lange die Fischerei auf die küstennahen Zonen und auf den Betrieb mit Segelfahrzeugen beschränkt blieb, war der Bestand nicht gefährdet. Bei Nutzfischen, die unter ungünstigen ökologischen Bedingungen in der Ostsee leben, wie die Scholle, waren allerdings, wie wir alten Berichten entnehmen können, die Wirkungen einer Fluktuation nach der negativen Seite hin bereits damals zu spüren. Aber die dadurch hervorgerufenen Ausfälle in der Fischerei waren nichts Dauerndes. Das Auftreten eines guten Jahrganges vermochte den Bestand wieder auf die gewohnte Höhe zu bringen. Heute bestehen gänzlich veränderte Verhältnisse. Das hat die dauernd gesteigerte Fischerei mit Motoren bewirkt.

In Deutschland datiert die Einführung des Motors ungefähr vom Jahre 1901 ab. Die Einführung ging aber so langsam vor sich, dass ein schädigender Einfluss auf den Bestand nicht zu bemerken war. Dazu waren noch andere den Bestand schonende Faktoren vorhanden. Zwar betrug das Mindestmass für Schollen und Flundern der Ostsee in Deutschland vor dem Kriege nur 15 cm. (ganze Länge). Flunder und Scholle hatten aber natürliche Schonzeiten und Schonreviere. Mit den zu der Zeit vorhandenen nur kleinen Segelfahrzeugen, die nur in wenigen Fällen mit sehr schwachen Hilfsmotoren ausgerüstet waren, konnten die Fischer weiter entfernte Fanggründe nicht aufsuchen. Sie waren an die küstennahen Fanggründe gebunden, die ihnen damals ausreichende Fänge lieferten. Dazu verhinderte Windstille an vielen Tagen die Fischerei. Wenn schliesslich mit Eintreten der kalten und rauhen Jahreszeit die Fische nach den tieferen Gründen der Ostsee abwanderten, vermochten ihnen die Fischer nicht zu folgen, sodass damals die Plattfischfischerei in der mittleren Ostsee vom Herbst bis Frühling alljährlich 4 bis 6 Monate eingestellt war. Auch in der westlichen Ostsee trat während des Winters eine Schonung der Plattfischbestände ein, weil sich dort die Fischer dem ergiebigeren Herings- und Sprottfang in den geschützten Förden zuwandten. Wir können diese Periode ungefähr bis zum Jahre 1916 rechnen. Die Hungerblockade während des Weltkrieges und die Inflationszeit zwangen Deutschland zur stärksten Ausnutzung aller vorhandenen Nahrungsquellen. Dadurch wurde eine Intensivierung der deutschen Ostseefischerei besonders nach der technischen Seite hin eingeleitet, die heut noch nicht zum Abschluss gekommen ist. Über diesen technischen Ausbau der deutschen Ostseefischereiflotte geben folgende Zahlen Auskunft.

In der deutschen Ostseefischerei zählte man bis zum Jahre:

1904 523 Kutter, davon 17 mit Hilfsmotor bis 5 PS-Stärke.

1916 533 Kutter, davon 266 mit Motor, davon 263 von 4—12 PS-Stärke, und je 1 von 20, 25 und 40 PS.

1929 759 Kutter, davon 731 mit Motor, meist etwa 10—20 PS, aber schon 106 von 25 und über 25 PS, darunter 2 von 50, 4 von 60, 1 von 70 PS.

1937 800 Kutter, davon 793 mit Motor, meist 20—40 PS, aber schon 252 von 50 und über 50 PS, darunter 9 von 100 PS und 2 von 140 PS.

In Wirklichkeit ist die Vergrösserung der Kutteranzahl erheblicher als oben angegeben, da in den Zahlen für die Jahre 1904 und 1916 die Kutter in den abgetretenen Gebieten Nordschleswig, Westpreussen und Memel enthalten sind. Es müssten, um ein richtiges Bild zu erhalten, den Angaben für 1929 und 1937 die nicht unbeträchtliche Zahl grosser Kutter hinzugefügt werden, die in Polen und Memel beheimatet sind.

Hand in Hand mit der Einführung stärkerer Motoren ging eine Vergrösserung der Fahrzeuge und besonders der Fanggeräte. Die Scherbrettzeese, die im Jahre 1903 in die deutsche Fischerei eingeführt wurde, hatte damals eine Öffnung von 7 m. Das heute gebräuchliche Schleppnetz hat eine Öffnung von 120 Fuss = 37 m., also das Fünffache. Dazu kommt, dass infolge der stärkeren Motorkraft das Netz schneller über den Grund gezogen wird, also mehr als das fünffache Areal wie die ursprüngliche Scherbrettzeese befischt.

Die Einführung grösserer seetüchtigerer Fahrzeuge mit starken Motoren machte die Fischer von Wind und Wetter unabhängiger. Das brachte mit sich, dass die natürliche Schonzeit während der Wintermonate, von der oben die Rede war, verschwand. Die Fischer verfolgten die abwandernden Plattfische bis in die Tiefen und befischten in starkem Masse die laichreifen Schollen und Flundern auf den Laichgründen. Zwar ist seit einigen Jahren durch Einführung der internationalen Schonzeiten für Scholle und der deutscherseits eingeführten Schonzeit für Flunder die Befischung der Laichgründe beschränkt. Die Schutzmassnahmen vermochten jedoch nicht, die schädigende Wirkung der für den Bestand unstreitig zu starken Fischerei aufzuheben.

Im Gegensatz zur Nordsee hat die Ostsee keine Kriegsschonzeit gehabt. Zwar wurde die Fischerei in den ersten beiden Kriegsjahren durch die Einberufung vieler Fischer zur Marine eingeschränkt, was sich im Rückgang des Ertrages ausdrückt, (vergl. Anhang Tab. 1) aber schon im Jahre 1917 und 1918 wurde sie in verstärktem Masse aufgenommen. Von da ab datiert der immer stärkere Eingriff in den Plattfischbestand durch die Fischerei infolge der technischen Entwicklung des Betriebes.

In Vorstehendem wurden nur die deutschen Verhältnisse dargestellt. Es besteht aber kein Zweifel, dass sich die Entwicklung in Dänemark, Schweden und Polen in ähnlicher Weise vollzogen hat.

II.

Bis ungefähr zum Jahre 1909 konnte sich die Schollenfischerei auf einen überalterten Bestand stützen. Zum Beweis seien zunächst zwei Altersanalysen von Fängen aus der westlichen Ostsee aus den Jahren 1909—1911 gegeben, die Johansen auf Grund des Materials von Reibisch zusammengestellt hat. (S. a. Fig. 2.) Die angegebenen Längen sind die Durchschnittsgrössen für jede Altersgruppe

	Kieler Bucht bei Fehmarn Belt		Fehmarn Belt bei Kadettrinne	
	♂ cm.	♀ cm.	♂ cm.	♀ cm.
I Gruppe	10·5	10·7	—	12·5
II „	16·5	16·9	15·7	15·0
III „	17·8	19·4	18·1	19·1
IV „	18·8	21·9	18·9	20·6
V „	20·8	22·8	20·1	22·5
VI „	22·3	23·8	21·3	23·8
VII „	22·4	23·9	21·0	24·6
VIII „	25·0	26·8	23·8	24·8
IX „	29·5	26·7	—	25·9
X „	25·5	27·2	21·0	27·6
XI „	—	30·6	—	27·8
XII „	—	29·0	—	29·0
XIII „	—	27·3	—	30·0
XIV „	—	33·0	—	29·0
XV „	—	29·2	—	38·0
XVI „	—	—	—	32·5

Wie man sieht, waren in den Fängen Männchen bis zur X-Gr. und Weibchen bis zur XVI-Gr. vertreten. Die Fischerei baute sich auf eine grosse Zahl von Jahrgängen auf, aber die Schollen blieben klein. Die Durchschnittslänge von Schollen der V-Gr., also Tiere im 6. Jahr, betrug nur 20·8 cm. bei Männchen und 22·8 cm. bei Weibchen. Nach der Gewichtsanalyse wogen die Männchen dieser Grösse im Durchschnitt ca. 80 g. bei einem Ernährungskoeffizienten von 0·81, die Weibchen von 22·8 cm. ca. 118 g. bei einem Ernährungskoeffizienten von 0·91.

Das langsame Wachstum der Schollen in der damaligen Zeit fand auch seinen Ausdruck in dem niedrigen Mindestmass, das dem biologischen Mindestmass — allerdings der Männchen — ungefähr entsprechend eingeführt worden war. Es betrug damals in Deutschland 15 cm. vom Maul bis zum Ende der Schwanzflosse. Das zeigen uns deutsche und dänische Analysen der Laichreife an Schollen der westlichen Ostsee aus den Jahren 1909—1911, von denen als Beispiel eine Tabelle von Johansen gegeben sei. Die Schwankungen in seinen Zahlen bei den weiblichen Schollen rühren von dem zu kleinen Material her. Es sind daher für die Weibchen in der letzten Spalte zum Vergleich die Zahlen aus grösserem eigenen Material aus demselben Gebiet gegeben. (3)

Es waren reif von

	♂ (nach Johansen)	♀	♀ (nach Fischer)
	%	%	%
13 cm.	—	—	—
14 „	80	—	—
15 „	100	—	1
16 „	97	50	5
17 „	97	33	13
18 „	98	60	50
19 „	99	57	67
20 „	99	58	77
21 „	99	61	88
22 „	100	83	93
23 „	100	65	93
24 „	100	81	98
25 „	100	93	100
26 „	100	83	100
27 „	100	100	100
28 u. mehr	100	100	100

Da die erste Laichreife bei Schollen gewöhnlich erst im 4. Jahre also bei der III-Gr. eintritt, geht aus der Übersicht hervor, dass zur damaligen Zeit infolge des dichten Bestandes die Männchen von nur 15 cm. Länge bereits ein Alter von 3—4 Jahren hatten. Desgleichen waren 50—60 % der Weibchen von 18 cm. Grösse von gleichem Alter. Diese Grössen entsprechen einem Durchschnittsgewicht von 30 g. bei den Männchen und von 59 g. bei den Weibchen. Wahrscheinlich trat aber infolge der ungenügenden Ernährung, die sich in dem geringen Wachstum ausdrückt, bei vielen Individuen eine Verzögerung im Eintritt der ersten Laichreife ein. Zwar waren bei den Männchen die der III-Gr. zu 91·1 %, die der IV-Gr. zu 100 % laichreif. Bei den Weibchen fand Johansen in der westlichen Ostsee aber folgende Streuung:

II	Gruppe	0 % laichreif
III	„	26·5 % „
IV	„	72·9 % „
V	„	89·2 % „
VI	„	97·0 % „
VII	„	100·0 % „

Ähnliche aber noch ungünstigere Verhältnisse fanden sich auch bei der Flunder der mittleren Ostsee. Hier konnten schon viele Weibchen gefunden werden, die bereits bei nur 13 cm. Grösse laichreif waren. Dass das geringe Wachstum der Flundern in der offenen See in dem zu dichten Bestand seine Ursache hatte, ging aus dem Vergleich mit den Flundern aus dem weniger dicht besiedelten Greifswalder Bodden hervor. Hier wuchsen die Flundern erheblich schneller. Weibchen von 17—18 cm. waren noch unreif, die erste Laichreife wurde erst bei einer Grösse von 20—23 cm. erlangt.

Wie wirkte die mit 1917 einsetzende immer stärkere Fischerei auf den Bestand ein?

Es ist klar, dass durch intensivere Fischerei zuerst die grösseren, ohnehin in geringerer Zahl vorhandenen Fische ergriffen werden. Das hat eine allgemeine Rückwirkung auf den Bestand. Bei den Plattfischen sind die Weibchen grösser als gleichalterige Männchen. Männchen über 30 cm. gehörten bis 1917 zu den Seltenheiten. Durch das Wegfangen der grösseren Tiere werden also in erster Linie die biologisch wertvolleren Weibchen getroffen. Ferner nimmt bekanntlich die Produktion der Eimenge mit der Körpergrösse ganz ausserordentlich zu. Franz gibt für die westliche Ostsee folgende Mittelwerte:

Weibchen	von	21—25 cm.	liefern	55,400 Eier
„	„	26—30 „	„	87,600 „
„	„	31—35 „	„	187,000 „
„	„	36—40 „	„	339,346 „

Die stärkere Vernichtung der grossen Weibchen hat daher einen Rückgang in der Eiproduktion zur Folge.

Gleichzeitig werden aber in verstärktem Masse die mittleren Grössen durch die Fischerei vernichtet. Da diese aus laichreifen Tieren bestehen und das Wachstum nach Eintritt der Laichreife verlangsamt ist, macht sich bald auch eine Abnahme dieser mittleren Grössen in den Fängen bemerkbar und es muss wiederum eine Abnahme in der Eiproduktion eintreten. Das braucht bei der grossen Zahl der Eier, die ein Weibchen abgibt, an und für sich noch keine Bedrohung des Bestandes zu bedeuten. Es wird sich aber auf den Bestand ungünstig auswirken, wenn eine Fluktuation nach der negativen Seite eintritt, d.h. wenn der Nachwuchs eines oder mehrerer Jahrgänge hintereinander gering ist oder ganz ausfällt. Besonders macht sich das bei den Nutzfischen bemerkbar, die, wie die Ostseescholle, in ungünstigen äusseren Verhältnissen leben, bei denen somit derartige Ausfälle häufiger vorkommen und auch die grösseren Tiere durch früheres Eintreten des natürlichen Absterbens stärker gefährdet sind. Da aber, wie wir wissen, solche Fluktuationen im Laufe der Jahre bei allen Nutzfischen vorkommen, wird sich früher oder später, namentlich wenn — wie in der Ostsee — die Befischung noch zunimmt, auch bei Fischen, die unter optimalen Lebensbedingungen leben, die Wirkung auf den Bestand einstellen. Diese braucht im Anfang nicht immer in einem Rückgang der Erträge ihren sichtbaren Ausdruck (Statistik) zu finden, sie zeigt sich aber in Veränderungen des inneren Aufbaues des Bestandes. (Vergl. Fig. 1, S. 102).

Bei der Ostseescholle war infolge zu starker Befischung folgendes eingetreten. Der Bestand baute sich nur aus wenigen Jahrgängen auf und infolge der Verdünnung des Bestandes war die Nahrung reicher und damit das Wachstum grösser. Die folgende Tabelle zeigt die Veränderung durch den Vergleich der Bestände aus den Jahren 1909—1911 und 1929—32 aus dem gleichen Gebiet.

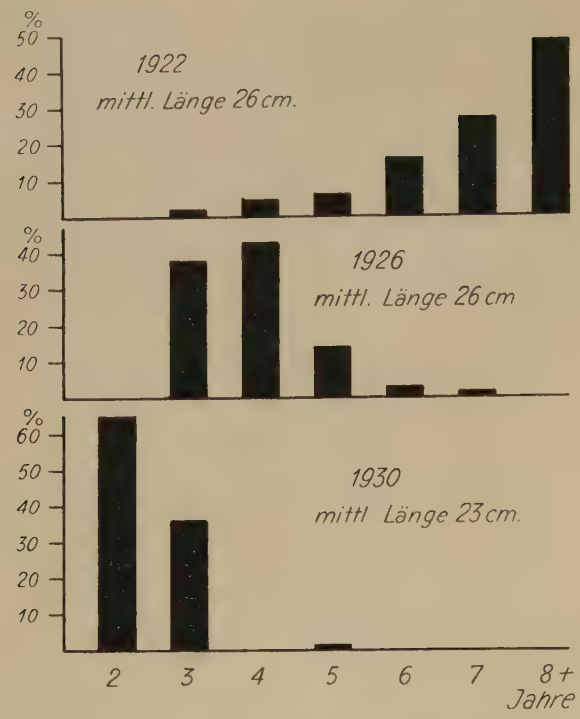

Fig. 1. Die altersmässige Zusammensetzung der Marktfänge von Schollen der mittleren Ostsee in verschiedenen Jahren. (Nach Strodtmann und Kändler).

Durchschnittsgrössen- und Gewichte der Schollen-Altersgruppen in der westlichen Ostsee (Fehmarnbelt bis Kadettrinne).

	1909—1911 ♂ und ♀		1929—1932 ♂ und ♀	
	cm.	g.	cm.	g.
I Gruppe	12·5		—	
II „	15·4	= 35	23·9	= 126
III „	18·6	= 60	27·1	= 169
IV „	19·8	= 71	32·5	= 295
V „	21·3	= 89	36·1	= 360
VI „	22·6		—	
VII „	22·8		—	
VIII „	24·3		—	
IX „	25·9		—	
X „	26·8		—	
XI „	27·8		—	
XII „	29·0		—	
XIII „	30·0		—	
XIV „	29·0		—	
XV „	38·0		—	
XVI „	32·5		—	

Wir sehen, dass in den Jahren 1909—11 sich der Bestand aus 16 Jahrgängen zusammensetzt, 1929—32 dagegen nur aus 5. Dazu ist die mittlere Grösse der Tiere der gleichen Altersgruppe sehr

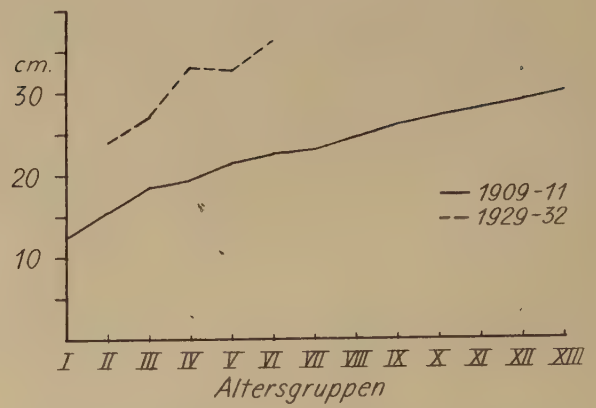

Fig. 2. Zunahme der Durchschnittslänge von Schollen gleicher Altersgruppen in der westlichen Ostsee (Fehmarnbelt—Kadettrinne) Jahre 1909—1911 und 1929—1932.

erheblich gestiegen. Wir finden in den einzelnen Altersgruppen Differenzen von 8·5 bis 13·5 cm. Noch erheblicher sind die Unterschiede im Gewicht. Das biologische Mindestmass verschiebt sich infolge der Raschwüchsigkeit stark nach oben. Während es in der westlichen Ostsee früher für die Männchen bei ca. 15 cm., für die Weibchen bei ca. 18—20 cm. lag, sind heute dort die Männchen erst bei ca. 23—24 cm., die Weibchen erst bei ca. 27—29 cm. laichreif. Das bedeutet wieder einen schweren Nachteil für die Erhaltung des Bestandes. Denn bei diesen Grössen sind die Schollen schon sehr gut marktfähig und die Männchen und vor allem die grösseren Weibchen werden bei der intensiven Befischung des dezimierten Bestandes zu einem sehr hohen Prozentsatz weggefangen, ehe sie einmal haben laichen können. Deshalb dürfte heute in der Kieler Bucht das Ablaichen der Schollen nur in so geringem Umfange stattfinden, dass an eine Erhaltung des Bestandes nicht zu denken ist. Praktisch zeigt sich dieser Zustand darin, dass auf den Küstenplätzen, auf denen man vor dem Kriege die 0-Gr. in grossen Mengen vorfand, heute die kleinen Schollen kaum noch anzutreffen sind. Auch in anderer Beziehung ist die Prognose für die neue Entstehung eines genügenden Bestandes an Schollen in der Kieler Bucht sehr schlecht. Denn zur Zeit ist das Wachstum durch die fortschreitende Verdünnung des Bestandes so gross, dass heute schon die I-Gr. befischt wird. Schollen dieser Gruppe erreichen dort bereits eine mittlere Grösse von 24·36 cm., bei einer Streuung von 21—27 cm.

Ähnlich aber etwas anders ist das Bild, das die Einwirkung der intensiven Befischung auf den Flunderbestand der mittleren Ostsee zeigt. Wie bereits oben gesagt, lebt die Flunder dort unter optimalen Lebensbedingungen. Der Einfluss der starken Befischung trat daher dort anfangs nicht so deutlich in Erscheinung. Gute Jahrgänge führten dem Bestand immer wieder neuen Nachwuchs zu.

Aber bereits im Jahre 1927 war das erste Anzeichen einer Überfischung auch der Flunder zu bemerken: das Fehlen der grossen Flundern. Diese werden an unseren Küsten vornehmlich von den Küstenfischern auf Stellnetzen gefangen. In den Jahren 1927 und 28 war auf den altgewohnten Fangplätzen dieser Fische eine solche Verarmung an grossen Flundern eingetreten, dass die Fischer den Fang mit Stellnetzen aufgeben mussten. (6) Vom Jahre 1929 an konnte der Fang wieder in beschränktem Umfange aufgenommen werden, aber die grossen Flundern, die seitdem an der Küste gefangen werden, stammen nicht mehr aus alten Jahrgängen, sondern es sind junge Tiere, die infolge der Verdünnung des Bestandes raschwüchsiger geworden sind und heute bereits als IV- bis VI-Gr. die Grösse erreichen, die früher 10- bis 15-jährige Flundern hatten.

Der Eingriff der verstärkten Fischerei in den Bestand hat sich seit 1926 bei der Flunder der mittleren Ostsee in derselben Weise vollzogen wie wir es bei der Scholle beobachten konnten, nur in langsamerem Tempo. Die Wachstumsbeschleunigung infolge der Verdünnung des Bestandes zeigt die folgende Übersicht nach Untersuchungen von P.-Fr. Meyer an Flundern aus dem Bornholmbecken.

	1930			1934			1937
	% vom Gesamtfang	Mittelwert	Grenzwerte	% vom Gesamtfang	Mittelwert	Grenzwerte	Mittelwert
		cm.	cm.		cm.	cm.	cm.
III-Gr.	13	**21·4**	18—25	29	**23·6**	20—27	**25**
IV-Gr.	30	**23·4**	19—29	57	**25·3**	20—34	**28**
V-Gr.	36	**25·6**	20—33	11	**26·2**	22—34	**30**
VI-Gr.	9	**27·9**	22—34	2	**30·8**	28—34	**32**
VII-Gr.	12	**30·0**	26—36	1	—	—	**38**

Entsprechend der Wachstumsbeschleunigung ist auch bei der Flunder eine Erhöhung des biologischen Mindestmasses eingetreten. In den Jahren 1906—12 waren Weibchen, die schon bei einer Grösse von 13·5 cm. laichreif waren, nicht selten. Heute fällt es schwer, laichreife Weibchen bei einer Länge von 23—24 cm. zu finden. Ebenso ist die Fülle der Jahrgänge, auf denen sich die Fischerei früher aufbaute, geschwunden. Die Fischer sind heute auf 3 höchstens 4 Jahrgänge angewiesen. Das muss uns auch in Hinsicht auf die Erhaltung des Flunderbestandes der mittleren Ostsee mit grosser Besorgnis erfüllen. Denn der Ausfall von nur 2 Jahrgängen hintereinander kann bei dem derzeitigen Zustand schon eine Katastrophe bringen. Nur sehr energische gemeinsame Schonbestimmungen aller an der Fischerei der mittleren Ostsee beteiligten Staaten können meiner Meinung nach den bedrohten Bestand noch retten.

Nachdem wir im Vorstehenden nur von dem Schollenbestand der westlichen Ostsee gesprochen haben, erscheint es notwendig, nun auf den der mittleren Ostsee einzugehen, weil dort seit Jahren

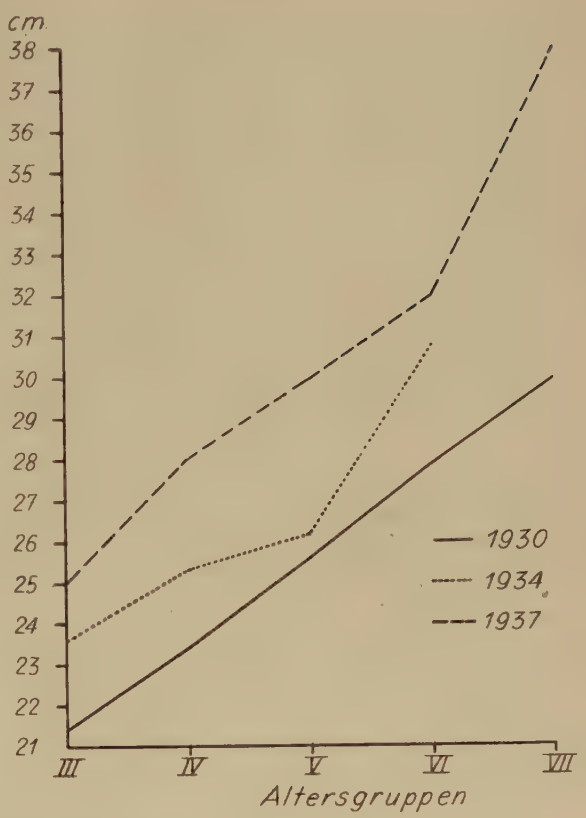

Fig. 3. Zunahme der Durchschnittslänge der Flundern gleicher Altersgruppen. Mittlere Ostsee. Jahre 1930, 1934, 1937.

der Schwerpunkt der Schollenfischerei in der Ostsee liegt (vergl. Anhang Tab. 2). Bis zum Jahre 1919 war östlich von Rügen die Schollenfischerei unbedeutend. Von 1920—22 nahm sie etwas zu bis auf 4747 dz., erreichte 1923 plötzlich fast 20,000 dz. und 1928 die grösste Höhe mit rund 41,000 dz. (S. a. Fig. 5). Zweifellos ist anfangs das Aufblühen dieser Fischerei auf das Aufsuchen bisher kaum oder wenig befischter Fanggründe zurückzuführen, wozu die Fischer durch die eingebauten stärkeren Motore besser befähigt waren. Vom Jahre 1926 ab treten aber auch Schollen in sehr grosser Zahl auf küstennahen Fanggründen auf, die bisher nur von Flundern besiedelt waren und wo Schollen früher überhaupt nicht oder nur in einzelnen Exemplaren in den Zeesenfängen vorgekommen waren. Es ist dies die Zeit, in welcher sich die Verdünnung des Flunderbestandes bemerkbar machte. Man hat diese Invasion der Scholle auf die alten Flunderfanggründe mit der Annahme erklären wollen, die Schollen hätten jetzt dort infolge der Verdünnung des Flunderbestandes Platz und genügende Nahrung gefunden. Wenn diese Annahme zutrifft, hätte die starke Befischung des

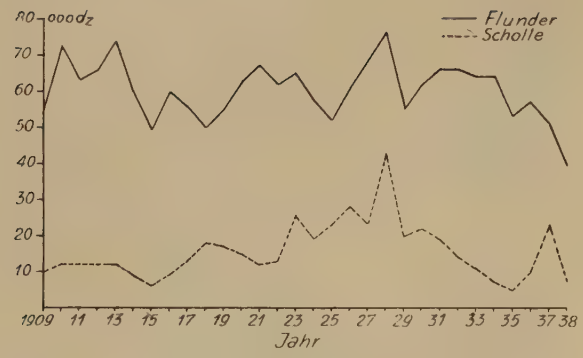

Fig. 4. Deutscher Gesamtfang an Scholle und Flunder in der Ostsee von 1909—1938 (in 1000 Doppeltzentner).

Bestandes eines Nutzfisches den Bestand eines anderen Fisches gefördert. Wie dem auch sei, jedenfalls ist auch der Schollenbestand der mittleren Ostsee bald von der intensiven Fischerei erfasst worden, und im Laufe weniger Jahre so stark dezimiert worden, dass der Ertrag im Jahre 1935 mit 4160 dz. wieder auf das Niveau des Ertrages von 1922 zurückgesunken war. (S. a. Fig. 5). 1935 setzte sich der Bestand für die 2 Zweige der deutschen Schollenfischerei in der mittleren Ostsee aus nur je *einem* Jahrgang zusammen und zwar für die Bornholmfischerei aus dem Jahrgang 1930, für die Küstenfischerei aus dem Jahrgang 1932, da der Nachwuchs aus den Jahren 1931 und 1933 so gering war, dass beide Jahrgänge für die praktische Fischerei wenig Bedeutung hatten. Die intensive Fischerei hatte den Schollenbestand der mittleren Ostsee fast vernichtet.

Es bestand aber die Hoffnung auf eine Besserung, da K ä n d l e r durch seine Untersuchungen über die 0-Gr. der Schollen ein überaus reiches Auftreten des Jahrganges 1934 festgestellt hatte. Wir konnten diesen Jahrgang weiter verfolgen. Das durchschnittliche Wachstum war sehr gross. Im August 1936 wurde die Durchschnittsgrösse der II-Gr. mit 21·8 cm. festgestellt bei einer Streuung von 19—28 cm. Da bei einem Mindestmass von 21 cm. in jenem Gebiet das fangfähige Mass erreicht war, begann die Befischung des Jahrganges 1934 bereits im Juli 1936 in sehr grossem Umfange, da die jungen Schollen in Schwärmen auf den Fanggründen auftraten. Der Fangertrag stieg von 4,160 dz. im Jahre 1935 auf 9,120 dz., also um mehr als 100 %. Ein Abwandern auf die Laichplätze fand (als II-Gr.) nicht statt. Nur sehr wenige laichreife Männchen konnten dort angetroffen werden. (8) Der Jahrgang 1934, dessen Individuen im Sommer 1937 fast ausnahmslos die fangfähige Grösse erreicht hatten, war während des ganzen Jahres der Befischung ausgesetzt mit dem Erfolg, dass zwar der Fangertrag auf 22,117 dz. stieg, die Schollen aber trotz zeitweiser Erhöhung des Mindestmasses zum grössten Teil weggefangen worden waren, ohne dass sie Gelegenheit hatten einmal zu laichen. Im Laichgebiet waren daher im Frühjahr 1938 verschwindend wenig Tiere aus dem Jahrgang 1934 zu finden und im Jahre 1938 sank der Ertrag an Schollen in der mittleren Ostsee wieder auf *5,717 dz.* Die starke Befischung hat somit die Hoffnung auf eine Aufbesserung des Schollenbestandes zu nichte gemacht.

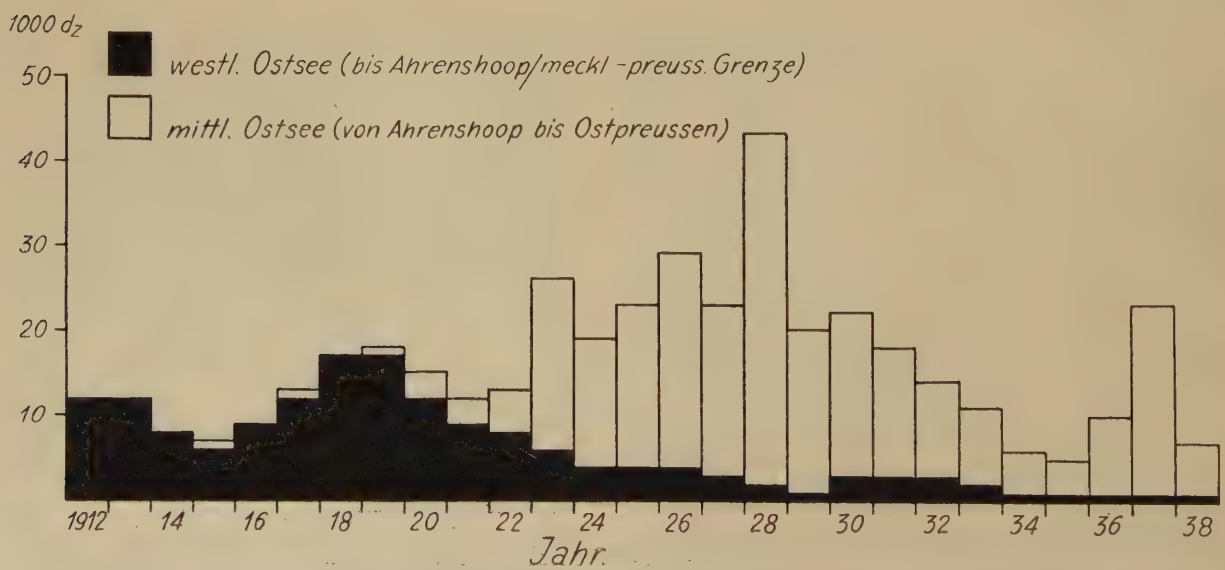

Fig. 5. Die Verschiebung der deutschen Schollenfischerei von der westlichen nach der mittleren Ostsee. Dargestellt aus den Jahreserträgen in 1000 Doppelzentner.

III.

Wir haben im Vorstehenden zum Teil katastrophale Veränderungen im Plattfischbestand der Ostsee in den letzten Jahren feststellen müssen. Wie sind solche Veränderungen, die einen zu starken Eingriff der Fischerei anzeigen, rechtzeitig zu erkennen? Wie bekannt, ist die allgemeine Statistik dazu nicht geeignet. Auch unser Material gibt dafür typische Beispiele.

Die Statistik des Gesamtfanges an Schollen (Anhang Tabelle 1) zeigt ein Aufblühen der Schollenfischerei bis zum Jahre 1928. Vergleicht man damit den Ertrag der Schollenfischerei in der westlichen Ostsee auf Tabelle 2, sieht man, dass dort bis zum Jahre 1928 schon ein gewaltiger Rückgang eingetreten ist. (S. a. Fig. 5). Der Ertrag der Schollenfischerei aus einem neuen Fanggebiet, der mittleren Ostsee, verdeckt die in der westlichen Ostsee eingetretene Katastrophe, die lediglich durch die Spezialstatistik zu erkennen ist.

Auch die Gesamtzahlen für die Flunder zeigen bis zum Jahre 1936 nichts Bedrohliches. Die Erträge sind verhältnismässig gleichmässig und die vorhandenen Schwankungen scheinen sich ohne weiteres durch Fluktuationen oder infolge äusserer Ursachen, gesteigerter oder verminderter Fischerei, erklären zu lassen. Die Jahre 1926—28, in denen sich, wie oben dargestellt ist, die ersten positiven Anzeichen eines stärkeren Eingriffs in den Bestand bemerkbar machten, weisen statistisch sehr gute Fangerträge auf. (S. a. Fig. 4). Es wird damit eine Blüte vorgetäuscht, die in Wirklichkeit nicht mehr besteht. Auch eine Berechnung des Ertrages je Reisetag oder Fangtag kann zu Täuschungen Veranlassung geben, wenn Veränderungen in der Fangkraft der Geräte durch stärkere Motoren oder vergrösserte Netze eintreten.

Zudem geben alle Statistiken den Fang nach Gewicht an. Ein tatsächlicher Ausfall in der Stückzahl tritt aber nach eingetretener Verdünnung des Bestandes gewichtsmässig nicht in Erscheinung, da durch die Raschwüchsigkeit grössere und damit schwerere Tiere gefangen werden. Auch die Längenmessungen allein geben wegen der Wachstumsbeschleunigung kein klares Bild.

Richtige Erkenntnis und Beurteilung der Veränderung im Bestand kann im wesentlichen nur durch genaue, regelmässig fortgesetzte marktstatistische Untersuchungen gewonnen werden, welche sowohl aus Längenmessungen, Altersbestimmungen, Gewichts-, Laichreife- und Geschlechtsbestimmungen bestehen. Zur Ergänzung und Abrundung des Bildes sind Untersuchungen über das Auftreten der I- und O-Gr. und kritische Heranziehung möglichst spezieller Statistiken aus begrenzten Gebieten notwendig.

IV.

Summary.

In respect of the Flat-Fish Stocks of the Baltic the following changes have been recorded during the last 30 years:

1. Larger specimen have been fished out.
2. Younger fishes have been subject to increased fishing.
3. The thinning of the stock has caused quicker growth of younger specimens.
4. The biological minimum-size has moved upwards.
5. The number of age-groups in the composition of the stock has decreased.

Through continued intensive fishing the growth-rate will increase to such extent that the legal minimum-size must be too far below the biological one. Too heavy catches of younger specimens will cause insufficient production of eggs, and the occurrence of poor brood-years may dangerously affect the entire stock. As confirmed by the 1934 year-class of plaice the fishery will be solely depending on fluctuations.

It is vitally important that any rich year-class to come must be protected by very strict regulations in order generally to rebuild the stock to be of lasting value to the fishery.

To avoid a catastrophy to the flounder-stock similar to that of the plaice-stock, general and uniform restrictions for protecting the existing stock are desirable as well as necessary.

Anhang.

Tabelle I.

Deutscher Gesamtfang an Scholle und Flunder in der Ostsee.

	Scholle dz.	Flunder dz.
1909	10,001	54,228
1910	11,721	72,589
1911	11,740	63,067
1912	12,428	66,397
1913	12,064	73,933
1914	8,596	59,995
1915	6,303	47,841
1916	9,240	60,255
1917	13,146	55,854
1918	17,564	50,367
1919	17,140	54,711
1920	14,895	63,112
1921	12,466	66,776
1922	12,524	62,009
1923	25,945	65,315
1924	19,088	56,576
1925	23,381	51,690
1926	28,409	61,881
1927	23,186	68,457
1928	43,011	76,461
1929	20,277	55,324
1930	21,870	61,771
1931	18,859	65,647
1932	14,261	65,571
1933	11,104	63,528
1934	6,548	63,705
1935	4,861	52,793
1936	9,994	57,144
1937	23,490	50,651
1938	6,836	39,458

Tabelle II.

Ertrag der Schollenfischerei in der

	westlichen Ostsee (bis Ahrenshoop/ meckl.-preuss. Grenze) dz.	mittleren Ostsee (von Ahrenshoop bis Ostpreussen) dz.
1912	12,295	133
1913	11,747	317
1914	8,473	123
1915	5,792	511
1916	8,947	293
1917	12,436	710
1918	17,404	160
1919	16,574	566
1920	12,102	2,793
1921	9,115	3,351
1922	7,777	4,747
1923	6,076	19,869
1924	3,919	15,169
1925	4,192	19,189
1926	3,822	24,587
1927	2,979	20,205
1928	2,340	40,670
1929	1,460	18,820
1930	2,630	19,240
1931	3,450	15,410
1932	2,770	11,490
1933	2,280	8,820
1934	1,400	5,150
1935	702	4,160
1936	874	9,120
1937	1,373	22,117
1938	1,119	5,717

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10.

DIE BEDEUTUNG DES "ÖKOLOGISCHEN JAHRESBERICHTES" FÜR DIE ARBEITEN DER INTERNATIONALEN MEERESFORSCHUNG.

VON

A. HAGMEIER.

Einleitung.

DIE Anregung unseres Präsidenten Herrn Prof. Hjort, die wichtigsten Ergebnisse der Grundlagenforschung der Seefischerei in jährlichen Berichten darzustellen, fiel auf fruchtbaren Boden, und es wurden von allen Vorsitzenden der Area-Kommissionen zustimmende Antworten gegeben, in denen bereits Einzelheiten über Inhalt und Form des Jahresberichtes, seine Veröffentlichung und seine Einordnung in die bisherigen Veröffentlichungen des Zentralausschusses der internationalen Meeresforschung enthalten sind. Das Ergebnis der Antworten wurde bereits vom Vorsitzenden des Beratenden Ausschusses, Herrn Dr. E. S. Russell zusammengefasst und mit seinen eigenen Gedanken in einem Diskussionsvorschlag zur Kenntnis gebracht[1]).

Zur Einleitung der Diskussion seien mir noch einige allgemeine Vorbemerkungen erlaubt:

Die praktische Seefischerei ist bestrebt, den Nutzfischbestand des Meeres so stark wie es technisch möglich ist auszubeuten. Wir können aus der Statistik der Anlandungen ersehen, in welchem Umfange der Vorrat des Meeres an Nutztieren jährlich in Anspruch genommen wird. Wir müssen uns aber dabei vor Augen halten, dass es sich bei diesem Vorrat nicht um totes Material, nicht um einen gleichförmig vorhandenen Bestand handelt, wie etwa beim Bergbau, sondern um Lebewesen, eine Tierbevölkerung, welche sich durch Geburt und Wachstum ständig ergänzt und entwickelt, oder auch durch natürliche Abgänge, Vernichtung durch Natureinflüsse, Tod — ausser dem Fang — verringert wird. Die Bestandsveränderungen des "Rohstoffes" Seefisch sind den Lebensgesetzen im Meere unterworfen. Die Lebensvorgänge im Meere beeinflussen also die Grundlagen der Seefischerei und der Mensch greift mit seiner Technik des Fischfanges in die Lebensgesetze ein; er beutet nicht einfach ein Rohstofflager aus.

Leider sind wir nicht, wie etwa ein Forstmann, in der glücklichen Lage, die Lebensvorgänge im Meer direkt wahrzunehmen und zu beobachten. Wir sind auf mehr oder weniger blinde Proben angewiesen und es gehört schon ein grosser Aufwand an Forschungsmitteln und wissenschaftlicher Arbeit dazu, die einzelnen Vorgänge aufzuklären.

Das war auch einer der wichtigsten Gründe der Organisation der Forschungsarbeit, welche in den einzelnen Völkern erfolgte und ausserdem für das internationale Meer zur internationalen Meeresforschung führte.

Der Förderung der organisierten internationalen Meeresforschung soll die neue Zeitschrift dienen und ich will kurz die Voraussetzungen für ihre Existenzberechtigung erörtern.

[1]) Siehe: Rapp. et Proc. Verb., Vol. No. 109, I, p. 30.

Die Faktorenketten der Lebensvorgänge im Meere.

Es handelt sich bei den natürlichen Grundlagen der Seefischerei um Lebenserscheinungen, welche durch verschiedene Faktorenkomplexe mit den Erscheinungen des unbelebten Lebensraumes verbunden sind. Wir müssen daher auch diese Erscheinungen in unsere Forschung einbeziehen. Wesentlich ist es dabei, nicht nur den augenblicklichen Zustand festzuhalten, sondern vor allen Dingen den *Verlauf* des biologischen Geschehens kennen zu lernen und die Veränderungen zu erfassen, welche die Meeresbiota ständig beeinflussen. Diese Vorgänge sind einmal jahreszeitlich gebunden und wir erhalten im Laufe des Jahres die Aspektfolge der Meeresbiota. Hinzu treten Verschiebungen in Raum und Zeit, ja es kann sich die Biota eines kleineren Gebietes qualitativ und quantitativ so ändern, dass ein anderes Bild entsteht. Wir nennen solche Folgen von verschiedenen Lebensgemeinschaften dann Sukzessionen. Neben dem regelmässigen normalen Verlauf der Lebenserscheinungen interessieren uns also besonders die im Laufe eines Jahres auftretenden Anomalien in der Folge des biologischen Geschehens. Sie sind gerade für die Entstehung von guten oder schlechten Jahrgängen einer Nutztierart von Bedeutung.

Auf der in Anlage 1 verteilten Übersicht habe ich die verschiedenen Faktorengruppen angegeben, welche das Geschehen im Meere beherrschen, soweit es für unsere Arbeiten von Interesse ist. Es sind das ja alles bekannte Tatsachen; ich will sie nicht alle aufzählen, sondern die Verknüpfung der Vorgänge nur an einigen Beispielen zeigen.

Die Klimafaktoren geben in vielen Fällen den Anstoss zu Anomalien; sie beeinflussen einmal die physikalischen Vorgänge im Wasser, einen Teil der hydrischen Faktoren, namentlich die Strömungen und den Temperaturverlauf; die Süsswasser- und Nährstoffzufuhr durch die Flüsse ist vom Klima,

Anlage 1. (10)

Die Meeresökologie in ihrer Bedeutung für die Seefischerei.

A. Der Lebensraum.

I. abiotische Faktoren:

1. Klimafaktoren: Meteorologische Erscheinungen und ihre Anomalien im betr. Jahr: Sonnenschein, Temperatur, Niederschlagsmenge.
   Windrichtung und Stärke (Sturmperioden).
2. Hydrische Faktoren: Strömungen und Transport der Wasserkörper (namentlich die Anomalien). Einstrom von ozeanischem Wasser in das Randmeer. Zufuhr von Flusswasser in das Randmeer. Verteilung der Nährsalze (P u. N), Änderungen von t° und S ‰.
3. Änderungen am Meeresboden: Umlagerungen des Sediments, z. B. Faulschlammbildung, O_2-Mangel.

II. biotische Faktoren:

1. Aspektfolge und Sukzessionen im Plankton: Wucherungen im Phytoplankton, im Zooplankton.
2. Transport und Änderung des Planktons in verschiedenen Wasserkörpern.
3. Massenentwicklung von Bodentierlarven und deren Verfrachtung.
4. Bildung von Flecken dichter Besiedelung der Bodenfauna (Fluktuationen). Vernichtung der Bodenfauna durch Kälte, Strömungen, Sedimentation.
5. Einschleppen ozeanischer Arten und ihr Schicksal.

B. Der Fisch.

1. Laichplätze: Lage und Laichmenge, Laichzeiten (Verschiebungen).
2. Schicksal der Fischbrut: Transport, Ernährung, Feinde.
3. Bestandsänderungen durch Fluktuationen, Stärke der Jahrgänge.
4. Wachstum der Fische: Nahrungsmenge im Plankton. Nahrungsmenge am Boden. Konkurrenz bei grosser Bestandsdichte.
5. Wanderungen und Ansammlungen der Fische: Nahrungswanderungen, Laichwanderungen. (Behinderung durch Plankton, Änderungen der Wanderungen durch hydrische Faktoren).

C. Der Mensch und die Fische.

1. Natürliche Bedingungen für den Ertrag der Fischerei:
   a. Fischgrösse und Menge.
   b. Verteilung der Fische nach Ort und Zeit.
2. Jahresverlauf der Fischerei:
   a. Art (Geräte und Fangplätze) der Fischerei.
   b. Stärke der Fischerei.
   c. Störungen.
3. Abfischen der Nutzfischjahrgänge.

der Niederschlagsmenge, abhängig und beeinflusst die chemischen Eigenschaften des Randmeeres.

Die Klimafaktoren wirken aber auch unmittelbar auf den belebten Lebensraum ein; sie beeinflussen die Aspektfolge des Planktons; direkt können sie auch auf die Laichzeiten der Fische und den Jahresverlauf der Fischerei einwirken. Auf dem Wege über die hydrischen Faktoren wird das Klima bisweilen die Ursache von reichlicher Entwicklung von Nahrung für die Fischbrut.

Der ganze Faktorenkomplex, welcher auf die Laichzeit, die Laichmenge und das Wachstum der Fischlarven einwirkt, ist wahrscheinlich die Ursache der verschiedenen Stärke der Jahrgänge der Nutzfische. Die Volksstärke hat wieder einen Einfluss auf das Wachstum der Grundfische, da die Nahrung am Boden nicht überall so reichlich ist, dass sie von beliebig vielen Verzehrern ausgenutzt werden kann (Nahrungskonkurrenz). Bei den Bodentieren bewirken ergiebige Brutzeiten und günstige Larvenverfrachtung Flecken dichter Besiedelung; handelt es sich dabei um als Fischnahrung wichtige Arten, so beeinflussen sie wieder das Wachstum der Fische. Stärke der Jahrgänge und Wachstum sind aber wieder bestimmende Faktoren für die Erträge der Fischerei.

In ähnlicher Weise wie bei den oben genannten Beispielen sind alle abiotischen und biotischen Faktoren des Lebensraumes der Fische verknüpft mit den arteigenen Lebensvorgängen der Fische und damit von grundlegender Bedeutung für die praktische Fischerei.

Die ökologische Forschung.

Es ist Ihnen bekannt, dass wir den Forschungszweig der Lebenskunde, der sich mit den Beziehungen der Lebewesen zu den Faktoren ihres unbelebten Lebensraumes und mit den Wechselbeziehungen der Bewohner desselben Lebensraumes befasst, als Ökologie bezeichnen. Nach einer kürzlich von Hans Krieg[1]) gemachten Bemerkung ist die

[1]) Zeitschrift "Der Biologe", *8*, H. 4, S. 127, 1939.

Ökologie nicht neu, sie hat begonnen, "führend zu werden, nicht etwa als alleinseligmachende Spezialwissenschaft, sondern ganz einfach als ein alles zusammenfassender Gedanke und ein alles beherrschendes Ziel. Kein Lebewesen steht ja isoliert und unabhängig inmitten seines Lebensraumes, jedes ist von ihm in Gestalt und Lebensweise bedingt, ist irgendwie an ihn angepasst. Aber jedes ist auch gleichzeitig ein mitbestimmender Faktor dieses Lebensraumes".

Die Meeresforschung betreibt schon seit Beginn ihrer Tätigkeit Meeresökologie. Die Forschungen bewusst nach den Methoden der Ökologie ausrichten, ist eine Aufgabe des neuen Jahresberichtes, für den ich daher den Namen *"ökologischer Jahresbericht"* vorschlage.

Es wird damit wie gesagt keine Neuerung eingeführt, sondern eine Forschungsrichtung, die Sie schon immer befolgt haben, im Interesse der Übersichtlichkeit mit dem richtigen Namen bedacht.

Bei der Empfehlung und Einrichtung des ökologischen Jahresberichtes möchte ich besonders auf zwei wichtige Forderungen hinweisen, welche an die Vorsitzenden der Area Komitees und an die sachverständigen Mitarbeiter zu richten sind.

1. Bei der Planung der Untersuchungen ist von vornherein die terminmässige Bearbeitung der wichtigsten Forschungsaufgaben im Lebensraum und in der Lebenskunde der Fische vorzusehen. Wir können, wie auch von Prof. Hjort betont wird, nur dann wertvolle Schlüsse ziehen, wenn die jährlichen Terminbeobachtungen lückenlos vorliegen. Welche Stationen, Schnitte oder Fangplätze zur Terminbeobachtung ausgeführt werden sollen, muss in den Areasitzungen bestimmt werden.

2. Die ökologische Forschungsweise erfordert gerade auf dem Meere eine enge Zusammenarbeit aller Forscher: die Sachverständigen für Plankton, für Fischbrut, für die engere Fischereiwissenschaft, für Ozeanographie müssen ständig in Verbindung miteinander bleiben und sich ihre Resultate bekannt geben, damit die entsprechenden Spezialuntersuchungen rechtzeitig angesetzt werden können. Es ist unsere Pflicht, diese Gemeinschaftsarbeit mit allen Mitteln zu fördern und unsere Ergebnisse der Allgemeinheit zur Verfügung zu stellen. Die Herren Dr. Clark und Dr. Bückmann wiesen besonders daraufhin, dass bei der Hergabe von noch nicht zu Ende bearbeiteten Forschungsergebnissen Prioritätsstreitigkeiten entstehen könnten. Bei gegenseitiger Fühlungsnahme und Zusammenarbeit im Interesse des Ganzen wird dieser Fall nicht eintreten. Zudem werden auch weiterhin an anderen Stellen grössere Spezialarbeiten, die nicht in den ökologischen Jahresbericht aufgenommen werden sollen, veröffentlicht werden.

Die Zeitspanne für den Jahresbericht.

Die meisten Vorsitzenden sind der Ansicht, dass als Berichtsjahr das Kalenderjahr angenommen werden sollte. Über die Fertigstellung des Jahresberichtes gehen die Vorschläge auseinander, es wird teils verlangt, dass der fertige Bericht zu den jährlichen Tagungen bereits vorliegen soll, teils wird vorgeschlagen, die einzelnen Beiträge zum Jahresbericht im Entwurf bei der jährlichen Tagung vorzulegen und seine endgültige Form zu besprechen, sodass der Bericht bis zum folgenden Herbst gedruckt vorliegt. Ich möchte vorschlagen, als Berichtsjahr die Zeit von November bis Oktober zu wählen, da diese Zeit ungefähr dem biologischen Jahr im Meer entspricht. Der Bericht könnte dann zu der jährlichen Tagung bereits gedruckt vorliegen. Was auf der Tagung zu besprechen ist, wäre dann das Arbeitsprogramm für das folgende Jahr.

Die Abfassung und Leitung des Jahresberichtes.

Es besteht allgemeine Übereinstimmung darin, dass der Jahresbericht von den Area-Vorsitzenden geleitet und herausgegeben wird. Eine Einteilung nach Fischarten oder Problemen kommt nicht in Frage, da jeder einzelne Lebensraum seine bestimmten Eigenarten hat, welche für die Lebensvorgänge wichtig sind. Dabei muss daran erinnert werden, dass die Spezialkommissionen verpflichtet werden müssten, den Area-Vorsitzenden ihre Forschungsergebnisse (Hydrographie, Plankton, Statistik) jeweils rechtzeitig zur Verfügung zu stellen.

Inhalt und Form des Jahresberichtes.

Für die Diskussion besonders wichtig ist die Frage nach Inhalt und Form des ökologischen Jahresberichtes. Hierzu haben eine Anzahl der Area-Vorsitzenden bereits Stellung genommen[2]). Die erste Frage ist:

Was soll der Jahresbericht enthalten?

Hier wird von einigen Herren betont, dass in erster Linie Ergebnisse derjenigen Forschungsarbeiten aufgenommen werden sollen, welche in unmittelbarem Zusammenhang mit der praktischen Fischerei stehen. Damit wollen sie wohl nur das praktische Endziel zum Ausdruck bringen, wobei die Notwendigkeit der ökologisch-wissenschaftlichen Grundlagenforschung nicht bestritten wird. Der Hauptzweck des ökologischen Jahresberichts soll ja sein, Zusammenhänge in den natürlichen Erscheinungen aufzudecken, die die Grundlage der Fischerei bilden. So ist es z. B. unser Bestreben, die Ursachen der für die praktische Fischerei so wichtigen Fluktuationen aufzufinden. Wir können dies nur dann, wenn wir die Vorgänge im Lebensraum der Fische eingehend studieren. Sie bilden die Grundlage für die engere Fischereiwissenschaft und dürfen nicht von ihr vernachlässigt werden.

Wir werden also in den Jahresbericht in erster

[2]) Die Beiträge der Area-Vorsitzenden sind im Leica-Archive aufbewahrt: Film Nos: ??? — ???. (Diapositiv wird auf Verlangen geliefert).

Anlage 2. (10)

Die Forschungsarbeiten auf den einzelnen Gebieten.

A. Der Lebensraum.

I. abiotische Faktoren:

1. Klima: Auswertung der von den meteorologischen Ämtern veröffentlichten Berichte.
2. Hydrographie: Terminbeobachtungen, hauptsächlich zu den Laichzeiten, an festgelegten Stationen. Beobachtungen bei den Forschungsfahrten. Strömungsberechnungen, Versuche mit Treibflaschen.
3. Bodenuntersuchungen bei den Forschungsfahrten.

II. biotische Faktoren:

1. Phänologische Planktonbeobachtungen bei den Forschungsfahrten und quantitative Terminfänge an bestimmten Stationen.
2. Verfolgung der Wasserkörper durch Bestimmung der Leitformen.
3. wie zu 1.
4. Quantitative Untersuchungen der Bodenfauna, möglichst terminmässig auf ausgewählten "Schnitten".
5. Beobachtungen während der Forschungsfahrten.

B. Lebenskunde der Fische.

1. Quantitative Eier- und Larvenfänge auf ausgewählten Schnitten durch die Laichgebiete.
2. Quantitative Larvenfänge im Verbreitungsgebiet auf ausgewählten Schnitten.
3. Wissenschaftliche Vergleichsfänge und Altersbestimmungen.
4. Durchschnittslängen der Jahrgänge, Mageninhaltsuntersuchungen in Verbindung mit **A** II 4. Markierungsexperimente.
5. Analyse wissenschaftlicher Fänge, Altersbestimmungen, Markierungsversuche, Rassenuntersuchungen. Statistische Bearbeitung der Marktfänge.

C. Fischerei.

1. Biologisch-statistische Untersuchungen:
   a. Analysen von Marktfängen in Verbindung mit der Marktstatistik.
   b. Ertragsstatistik nach Fangplätzen und Fang je Fischtag.
2. Zusammenstellungen nach der Marktstatistik.
3. Altersbestimmungen bei den Marktanalysen. Erträge einzelner Jahrgänge. Vergleiche mit den Ergebnissen von **B** 3 und **B** 5.

Linie solche Forschungsergebnisse des Lebensraumes und der Fische aufnehmen, welche sich zu einer Kausalreihe verbinden lassen. Das wird nach der von einigen Vorsitzenden gemachten Bemerkung besonders dann möglich sein, wenn schon jahrelange ähnliche Beobachtungsreihen vorliegen. Aber auch bei neu begonnenen Reihen wird es von Nutzen sein, die Ergebnisse im Jahresbericht aufzuführen, damit spätere Vergleiche und Rückschlüsse erleichtert werden. Wenn solche Beobachtungsreihen in den grossen Areagebieten nicht durchgeführt werden können, so ist es doch wahrscheinlich möglich, dass wichtige Teilgebiete in Angriff genommen werden. Die Ergebnisse der Forschungen über die Beziehungen zwischen den Vorgängen im Lebensraum und den Lebensvorgängen der Fische sollen dann in Verbindung gebracht werden mit den Ergebnissen der Untersuchungen über den Fischbestand, den Fischereiertrag und mit den Schwankungen, denen beide unterworfen sind.

2. Frage: In welcher Form sollen die Ergebnisse berichtet werden?

Zu dieser Frage betonen besonders Hjort und Bückmann, dass der Jahresbericht keine Sammlung von Rohmaterial sein soll. Es sollen nur die Ergebnisse der Untersuchungen in übersichtlicher Form dargestellt und veröffentlicht werden. Dabei sollen Karten und Kurvendarstellungen in weitgehendem Masse verwendet werden. Es wird die Aufgabe des Area-Vorsitzenden sein, bei der Redaktion des Jahresberichtes auf die grossen Beziehungen hinzuweisen, nachdem die einzelnen Verfasser schon bei ihren Spezialberichten namentlich die engeren Zusammenhänge zwischen den Lebensvorgängen und den Änderungen im Lebensraum erörtert haben.

Arbeitspläne für die einzelnen Areas sind von verschiedenen Vorsitzenden bereits angegeben, ein allgemeines Programm ist bereits vom Vorsitzenden des Consultative Committee Dr. E. S. Russell zusammengestellt. Ich habe diese Vorschläge alle in der in Anlage 2 verteilten Zusammenstellung übernommen, nur habe ich dabei dieselbe Anordnung gewählt, welche in Anlage 1 die verschiedenen Beziehungen zwischen Lebensraum, Fisch und Fischerei in eine Übersicht bringt.

Ich empfehle also, den Stoff des Jahresberichtes in dieser Weise anzuordnen. Anschliessend soll dann die Gesamtübersicht durch eine Darstellung des Area-Vorsitzenden gegeben werden.

Schlussatz.

Als wissenschaftliche Forscher haben wir alle das Verlangen, Ordnung zu bringen in die Fülle der Erscheinungen und Beobachtungen: unsere Einzelarbeiten sollen zusammengefasst werden zu einem übersichtlichen Bild, welches nicht nur einen augenblicklichen Zustand darstellt, sondern gleichzeitig erkennen lässt, wie sich die Vorgänge weiterentwickeln und welche Veränderungen dadurch eintreten.

Bei der Fischereiforschung genügt es nicht, eine noch so umfassende Darstellung des Lebens- und Fischreichtums eines Gewässers synoptisch aufzustellen, wenn es nicht möglich ist, aus der Dynamik der Vorgänge im Lebensraum, aus den Lebensgesetzen der Organismen und aus der Wirkung der Fischerei vorauszusagen, wie sich das Bild nach menschlichem Ermessen in den nächsten Jahren ändern wird.

Ist eine solche Voraussage möglich, so können wir Massnahmen treffen, den Ablauf der Vorgänge nach unserem Willen zu ändern. Das steht nur beim dritten Faktorenkomplex, bei der Fischerei selbst, in unserer Macht. Die Vorschläge zu solchen praktischen Massnahmen sind dann das schönste Ergebnis unserer organisierten wissenschaftlichen Zusammenarbeit zum Nutzen unserer Völker.